



IMM Quarterly Report: Winter 2021

MISO Independent Market Monitor

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Highlights and Findings: Winter 2021

- The MISO markets performed competitively this winter, despite frequent mitigation due to offer capping, and conduct was competitive overall.
- Extremely cold weather, tight conditions, and high gas prices in February contributed to a 75 percent increase in energy prices from last winter.
 - ✓ Average energy prices rose 10 percent in the first two months of the quarter and 226 percent in February because of the Artic Event in February.
 - ✓ In the first two months, gas prices increased by 24 percent over the prior year; however, in February gas prices were 12 times as high as in 2020.
- Average and peak load grew 3 and 8 percent, respectively, from last winter because of the colder conditions.
- Very high gas prices and transmission emergencies led to:
 - ✓ Real-time congestion at a record quarterly level of \$1.1 billion, which is more congestion than occurred in MISO during all of 2019; and
 - ✓ Real-time and day-ahead RSG totaled \$125 million and \$45 million, respectively. This includes costs verified above the \$1000 and \$2000/MWh soft and hard offer caps.
- Wind output continued to rise, peaking above 20 GW for the first time in December and February, roughly 5 percent higher than the prior record.

Quarterly Summary

		Value	Change ¹			Value	Change ¹		
			Prior Qtr.	Prior Year			Prior Qtr.	Prior Year	
RT Energy Prices (\$/MWh)	●	\$36.89	69%	75%	FTR Funding (%)	●	102%	95%	98%
Fuel Prices (\$/MMBtu)					Wind Output (MW/hr)	●	9,024	-6%	11%
Natural Gas - Chicago	●	\$8.79	319%	357%	Guarantee Payments (\$M)⁴				
Natural Gas - Henry Hub	●	\$3.39	50%	67%	Real-Time RSG	●	\$125.1	1131%	1596%
Western Coal	●	\$0.68	1%	-2%	Day-Ahead RSG	●	\$44.5	12%	566%
Eastern Coal	●	\$1.23	-1%	-7%	Day-Ahead Margin Assurance	●	\$18.7	207%	349%
Load (GW)²					Real-Time Offer Rev. Sufficiency	●	\$1.8	234%	679%
Average Load	●	77.7	13%	3%	Price Convergence⁵				
Peak Load	●	103.8	8%	8%	Market-wide DA Premium	●	0.1%	1.7%	2.4%
% Scheduled DA (Peak Hour)	●	97.9%	99.0%	98.8%	Virtual Trading				
Transmission Congestion (\$M)					Cleared Quantity (MW/hr)	●	17,562	-9%	14%
Real-Time Congestion Value	●	\$1116.2	192%	703%	% Price Insensitive	●	31%	32%	30%
Day-Ahead Congestion Revenue	●	\$463.0	127%	445%	% Screened for Review	●	2%	1%	0%
Balancing Congestion Revenue ³	●	\$46.5	-\$1.1	\$2.4	Profitability (\$/MW)	●	\$1.90	\$0.83	\$0.32
Ancillary Service Prices (\$/MWh)					Dispatch of Peaking Units (MW/hr)	●	588	776	835
Regulation	●	\$12.54	36%	74%	Output Gap- Low Thresh. (MW/hr)	●	237	176	38
Spinning Reserves	●	\$2.94	62%	71%	Other:				
Supplemental Reserves	●	\$1.55	455%	474%					

Key:

- Expected
- Monitor/Discuss
- Concern

Notes:

1. Values not in italics are the values for the past period rather than the change.
2. Comparisons adjusted for any change in membership.
3. Net real-time congestion collection, unadjusted for M2M settlements.
4. Includes effects of market power mitigation.
5. Values include allocation of RSG.



Highlights for Winter 2021

Arctic Event: Conditions in MISO and Neighboring Areas (Slides 20-22)

- Beginning on Feb. 12, arctic temperatures swept across the middle of the U.S., resulting in emergencies and alerts to be declared by MISO and its neighbors.
- Average and low temperatures throughout MISO on the coldest days from February 14-17 were 15 to 35 degrees below normal.
- This led to unusually large outages and derates in the Midwest and the South.
 - ✓ Almost 30 percent and 40 percent of the generation was out or derated in the Midwest and the South, respectively.
 - ✓ Roughly half of the outages and derates were forced outages and fuel supply shortages, both of which were substantially caused by the cold weather.
- Ultimately, this led to tight capacity conditions in some areas and reduced MISO's flexibility for managing congestion in some areas.
 - ✓ Some of these outages triggered emergencies that led to load shedding.
 - ✓ Neighboring areas were experiencing similar issues – conditions were most dire in SPP and ERCOT and both experienced system-wide load shedding.
- MISO operators performed admirably under extraordinary conditions, taking key actions in the face of simultaneous emergencies to protect the system.



Highlights for Winter 2021

Arctic Event: Natural Gas Price Volatility (Slide 23)

- Cold weather in MISO and in neighboring areas caused high demand for heating gas and supply interruptions.
 - ✓ Multiple gas wellheads experienced freeze-offs that limited gas supply, and power outages in TX led gas pipeline components to de-energize.
 - ✓ Between Feb. 12-16, gas prices in the Midwest soared from less than \$3 per MMBTU to hundreds of dollars at some locations (as high as \$700 at one).
 - ✓ Gas supply issues contributed to fuel supply outages of nearly 12 GW.
- Rapidly changing natural gas prices led to potential challenges in avoiding inappropriate market power mitigation and enforcing the soft offer cap of \$1000 per MWh.
 - ✓ IMM staff monitored day-ahead and intraday gas prices continuously throughout the event.
 - ✓ We adjusted generators' reference levels to reflect the most current gas prices and processed generator requests for reference level adjustments.
 - ✓ With these reference level updates, the mitigation software was used to effectively enforce the soft and hard price caps, as well as the standard market power mitigation.



Highlights for Winter 2021

Arctic Event: Impacts of External Transactions (Slide 24-26)

- Heavy flows from PJM to SPP and direct exports to SPP strained MISO's transmission and impacted Joint Parties (Southern Co. and TVA).
- Between February 14-19, MISO experienced an unprecedented amount of congestion caused by east-to-west flows across its system.
 - ✓ Real-time congestion totaled \$733 million, 70 percent of it in the South, and up to 33 constraints were violated at one point.
 - ✓ The most severe constraints were not M2M because they were not tested.
 - ✓ Although SPP had limited ability to help relieve the constraints, M2M coordination would have resulted in estimated payments from SPP to MISO of approximately \$50 million.
- The east-to-west flows caused multiple transmission emergencies, some of which resulted in load shedding, manual generator re-dispatch, and other actions to manage the constraints.
 - ✓ MISO took limited actions through transmission line-loading relief (TLR) and non-firm export cuts that provided tremendous relief.
 - ✓ Proactive use of these actions would have been beneficial, relieving the emergency constraints outside the western load pocket and the RDT.



Highlights for Winter 2021

Arctic Event: Emergency in the Western Load Pocket (Slide 24, 27)

- On Feb 15 -16, large generation outages in the pocket and some transmission outages led to extended firm load shedding and other high-cost actions.
 - ✓ The loss of 1300 MW of resources early on Feb. 15 triggered load shedding as high as 800 MW that lasted through noon on Feb. 16.
 - ✓ The constraints into the pocket were frequently overloaded and MISO declared a local transmission emergency (rather than a capacity emergency).
- MISO was able to maintain the stability of the system through this period, but we have identified a number of operational improvements:
 - ✓ The constraint into the pocket had previously been M2M but had been disabled and not retested – \$65 million in congestion was accrued and SPP would have owed MISO roughly \$10 million in M2M settlements.
 - ✓ High gas prices caused key units needed for managing the congestion to be more costly than the \$1000/MWh demand curve (TCDC) for the constraint.
 - This prevented the market from providing needed relief and compelled MISO to have to manually re-dispatch generation in the pocket.
 - Increasing the TCDC would improve the market’s ability to manage the reliability issues and improve pricing in the area.



Highlights for Winter 2021

Arctic Event: Pricing Issues in the Western Load Pocket (Slide 27)

- Most emergencies in a load pocket could be declared as a capacity emergency (EEA) or a transmission emergency.
 - ✓ Capacity shortages in a pocket will almost always lead to transmission overloads as the dispatch attempts to maximize imports into the pocket.
 - ✓ Unfortunately, the differences in pricing outcomes resulting from these two types of emergency declarations are stark.
 - ✓ After hurricane Laura, MISO declared EEAs and priced the area at VOLL.
 - ✓ In this case, MISO declared a transmission emergency and prices averaged only \$843 per MWh, which did not reflect system conditions. Conditions were similar in ERCOT where prices averaged \$7,500 per MWh.
- MISO should reform transmission emergency procedures, including raising the TCDC on the relevant constraint to (a) maximize the utilization of supply through the dispatch and (b) set efficient prices in the pocket.
 - ✓ Raising the TCDC to allow prices in the pocket to reflect VOLL would have:
 - Increased charges to generators that tripped offline by \$23 million.
 - Raised compensation to loads by \$29 million.
 - Balancing congestion would have risen by \$6 million.



Highlights for Winter 2021

Arctic Event: Conditions in the South Outside the Western LP (Slides 28-29)

- Outages and transmission flows through the South led to two transmission emergencies and a capacity emergency generally in the South.
- The first transmission emergency began on Feb. 15.
 - ✓ It generated more than \$100 million in congestion and resulted in a nuclear unit being manually ramped down to 28 percent loading, but no load shed.
 - ✓ A M2M test was not requested, but it would likely pass and would likely have resulted in payments from SPP of approximately \$40 million.
- The second emergency early on Feb. 16 resulted in a 1000 MW load shed.
- Conditions throughout the South were tight, and the external transactions counted as more than 1000 MW of RDT flow.
 - ✓ The RDT was significantly violated in the morning and evening.
 - ✓ The transaction cuts due to the LTE in the Midwest and the 1000 MW load shed in the South resolved the RDT violation in the morning.
 - ✓ 700 MW of load was shed in the evening for 2 hours.



Highlights for Winter 2021

Arctic Event: Lesson's Learned from the South Emergency

- In reviewing the unusual events that stress-tested the emergency procedures in the South, we identified the following opportunities for operational and pricing improvements:
 - ✓ Curtailing non-firm external transactions can mitigate sub-regional emergencies because it can reduce flows on the RDT;
 - ✓ Increasing the TCDC on the RDT would allow prices to move toward VOLL while ensuring that all available generation in the South is utilized;
 - ✓ To bring load back after it is shed in a subregion as quickly as possible, it may be necessary derate the RDT to create room for the load to return; and
 - ✓ Transmission emergencies did not produce efficient prices, in part because these emergency actions are not included in MISO's emergency pricing.
- Addressing these issues will provide MISO more options for responding to tight capacity conditions in the South while ensuring that prices efficiently reflect the emergency conditions.



Highlights for Winter 2021

Lessons Learned and Recommendations from the Arctic Event

- MISO's operators performed well under extremely stressful conditions.
 - ✓ They maintained the stability of the system and avoided the more severe reliability outcomes that occurred in neighboring markets.
- We identify some key lessons learned and improvements based on this event:
 1. Improve procedures to invoke TLRs earlier in advance of a transmission emergency and associated actions;
 2. Increase Transmission Constraint Demand Curves during emergencies to ensure pricing and dispatch reflects the emergency conditions;
 3. Derate the RDT after shedding load in a MISO sub-region to create headroom for load to return sooner;
 4. Modify sub-regional emergency procedures to utilize curtailments of non-firm exports that consume the RDT interface;
 5. Define and/or activate M2M constraints as quickly as possible to ensure partners provide available relief and pay for their share of the overloads.
 6. Ensure that emergency pricing and shortage pricing is applied consistently in capacity and transmission emergencies.



Submittals to External Entities and Other Issues

- We responded to several FERC questions related to prior referrals and FERC investigations. We continued to meet with FERC on a weekly basis and we responded to several requests for information on market issues.
 - ✓ We made several additional referrals and notifications during this period.
 - ✓ We have a number of investigations ongoing.
- We presented recommendations to the RASC and to FERC on reforming capacity accreditation to be based on availability during tight margin hours.
- We discussed several existing and new recommendations at the MSC, the Integrated Roadmap workshop, and the Scarcity Pricing workshop.
- We presented our Fall Quarterly Report to the Market Subcommittee.
- We met with OMS to discuss the latest market results, findings, and recommendations.

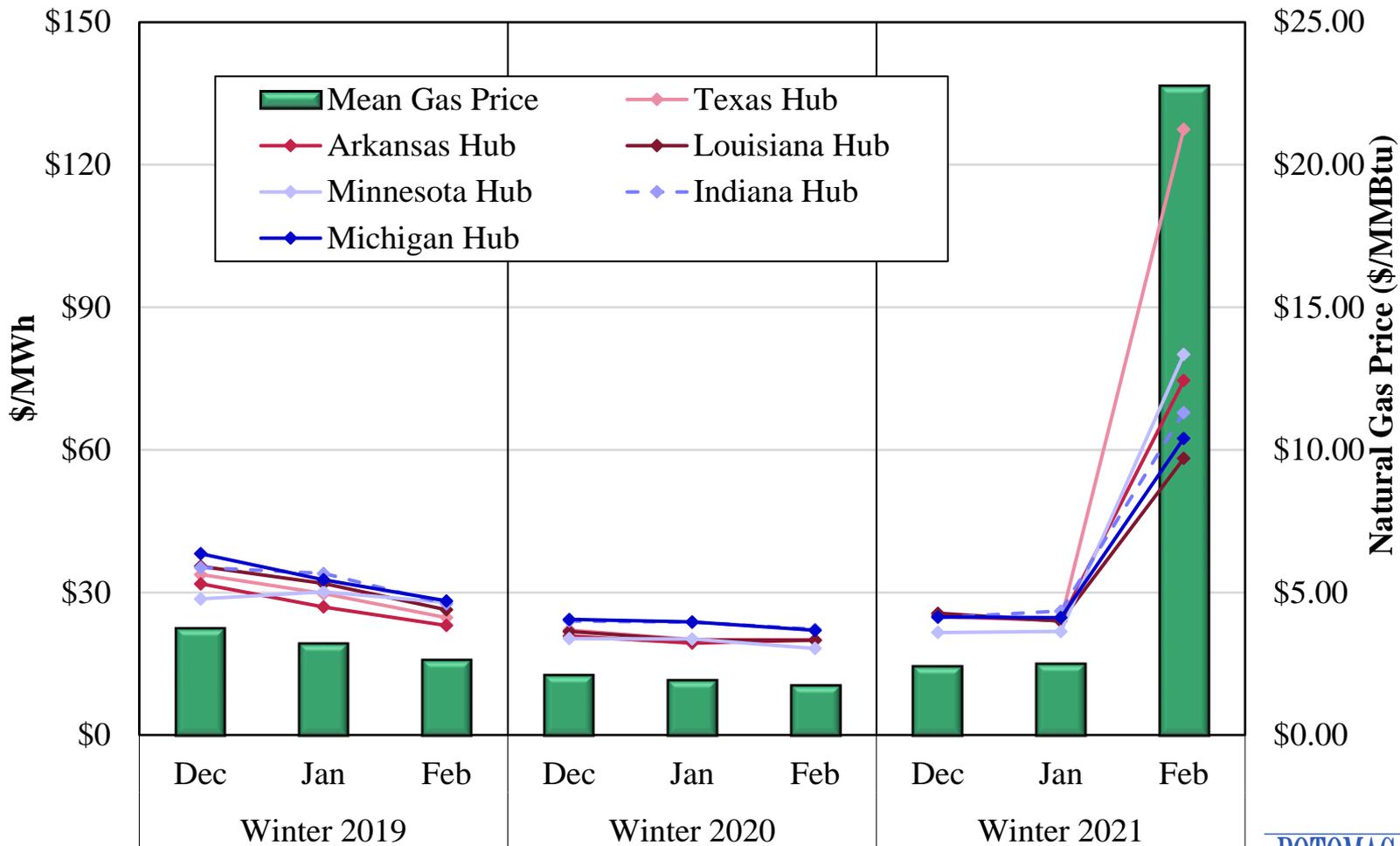


Submittals to External Entities and Other Issues

- We submitted detailed comments on Guiding Principles for DER development to the DERTF.
- We continued to discuss development of Ambient Adjusted Rating (AAR) Programs and use of Emergency Ratings with TOs and MISO.
 - ✓ FERC issued a proposed rule to require AARs that is largely consistent with our past recommendations (RM20-16)
 - ✓ We will be filing comments on this rulemaking, which are due in March.

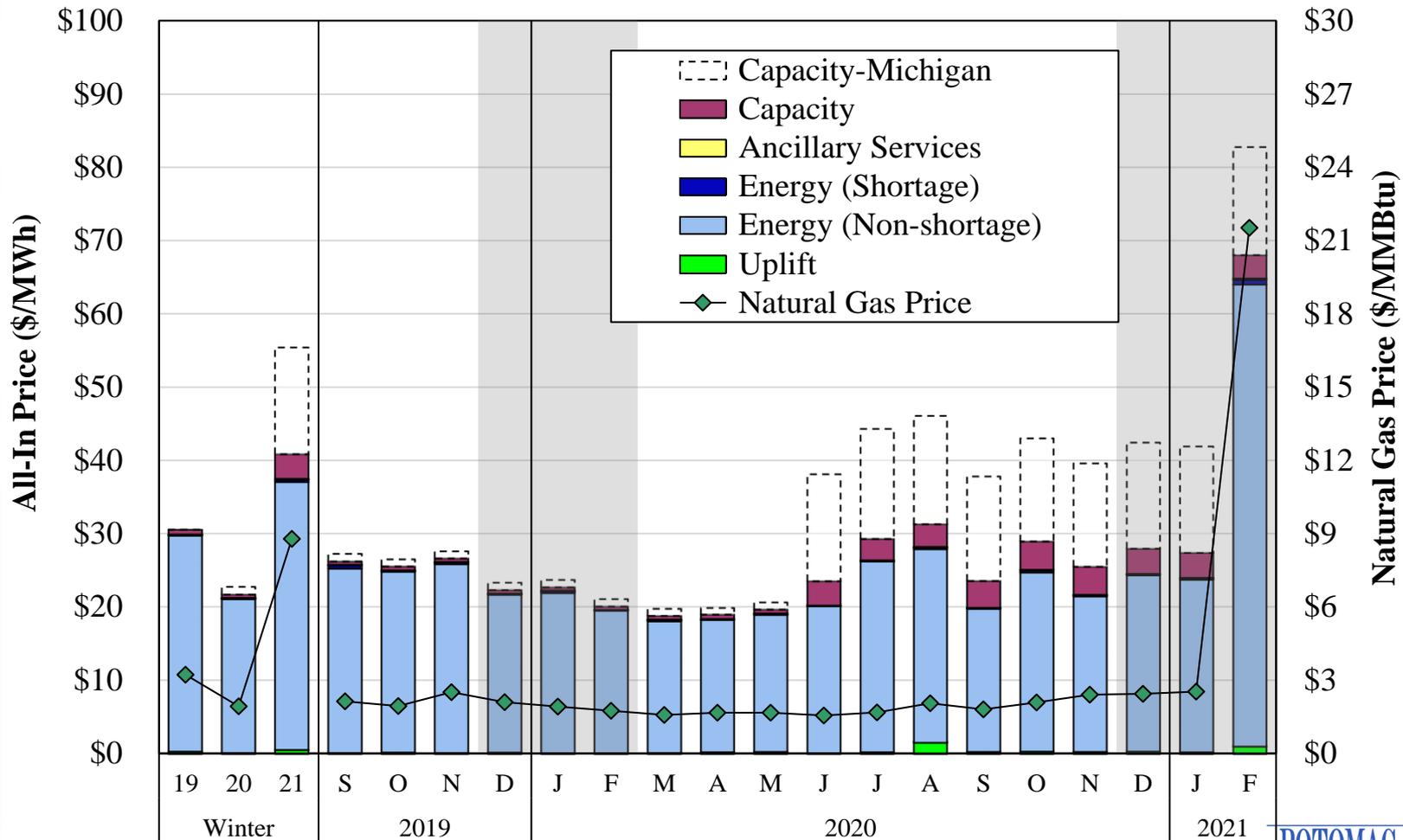


Day-Ahead Average Monthly Hub Prices Winter 2019-2021

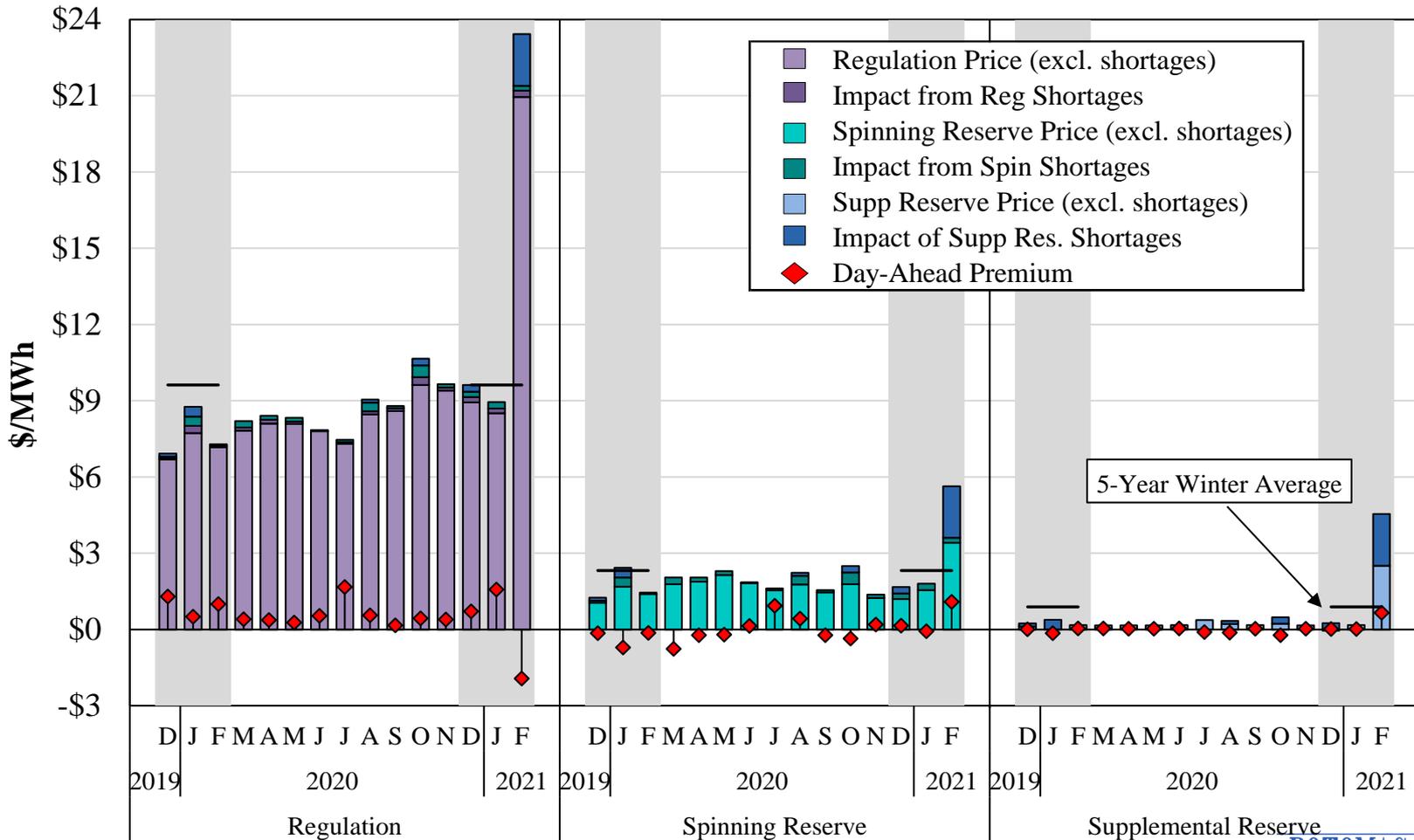




All-In Price Winter 2020 – 2021

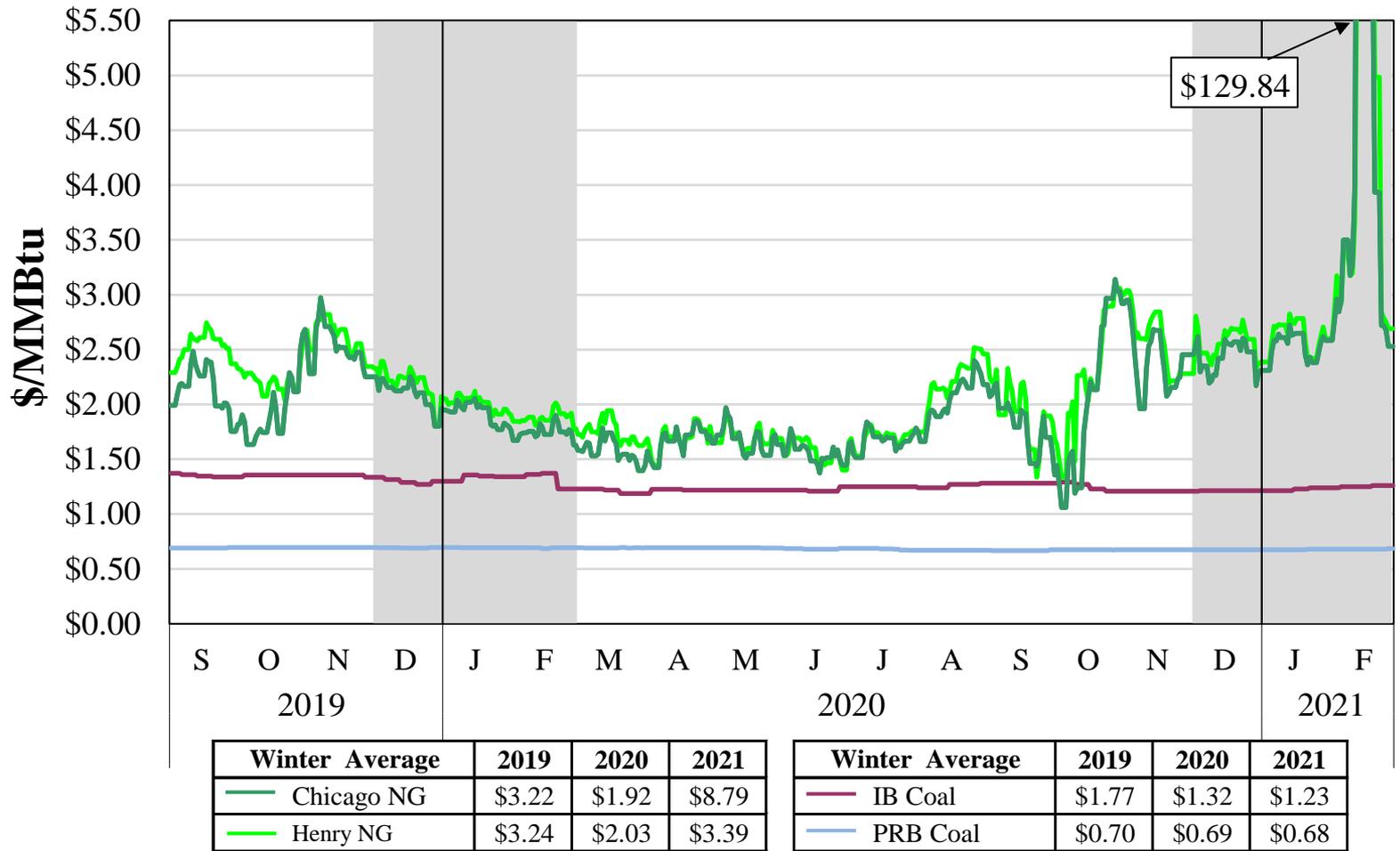


Ancillary Service Prices Winter 2020 – 2021



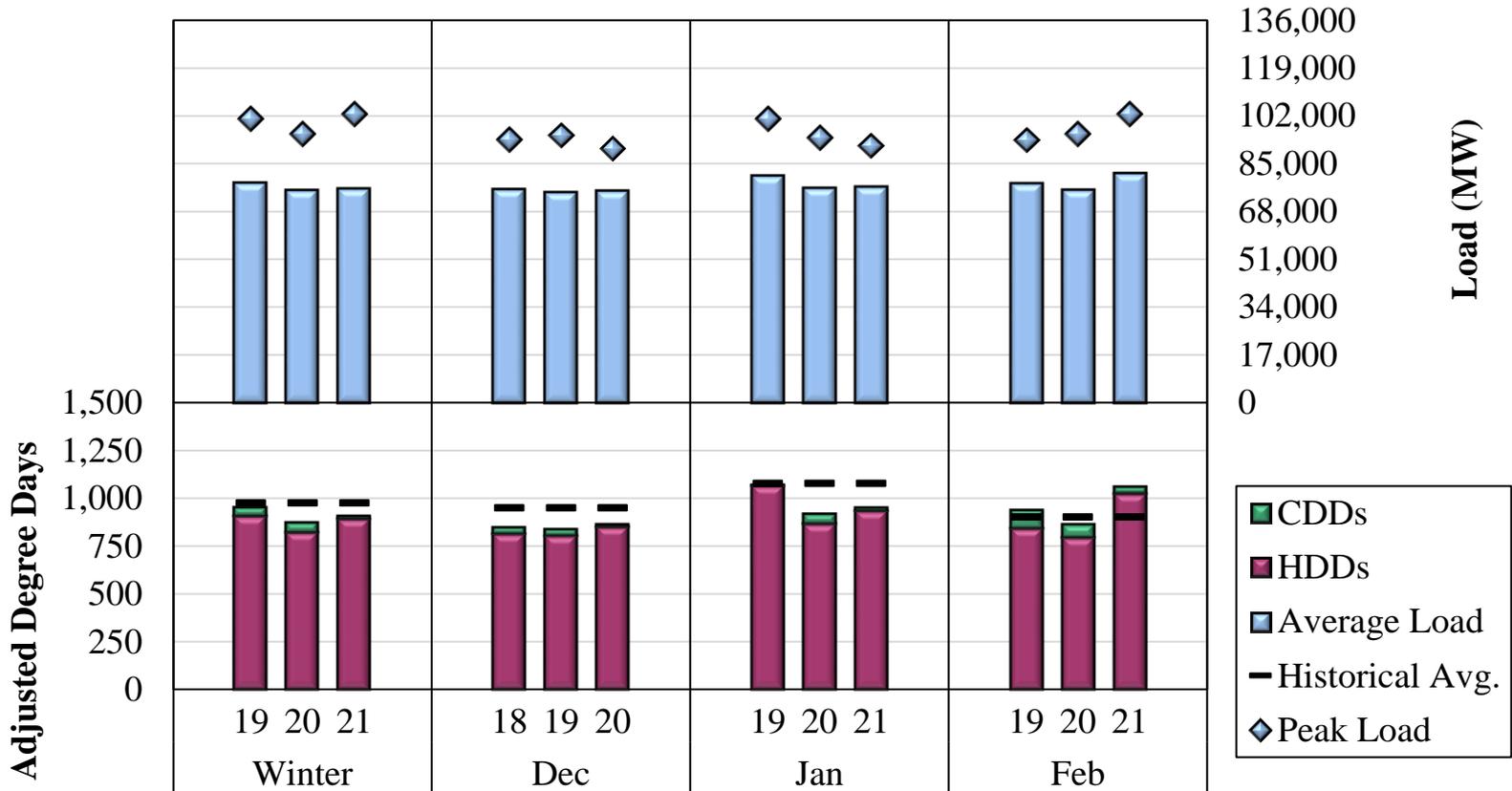


MISO Fuel Prices Fall 2019 – Winter 2021





Load and Weather Patterns Winter 2019 – 2021



Notes: Midwest degree day calculations include four representative cities: Indianapolis, Detroit, Milwaukee and Minneapolis. The South region includes Little Rock and New Orleans.

*COVID continues to have as small but significant effect on the load.

Capacity, Energy and Price Setting Share Winter 2020-2021

Winter	Unforced Capacity				Energy Output		Price Setting			
	Total (MW)		Share (%)		Share (%)		SMP (%)		LMP (%)	
	19/20	20/21	19/20	20/21	2020	2021	2020	2021	2020	2021
Nuclear	12,107	11,638	9%	9%	19%	16%	0%	0%	0%	0%
Coal	46,864	46,671	37%	36%	33%	42%	45%	46%	90%	88%
Natural Gas	56,673	58,462	44%	45%	34%	27%	52%	53%	98%	98%
Oil	1,568	1,578	1%	1%	0%	0%	0%	0%	0%	1%
Hydro	4,034	3,729	3%	3%	2%	1%	1%	2%	2%	2%
Wind	3,660	4,470	3%	3%	12%	13%	2%	0%	57%	56%
Other	2,703	3,211	2%	2%	1%	2%	0%	0%	1%	12%
Total	127,608	129,760								

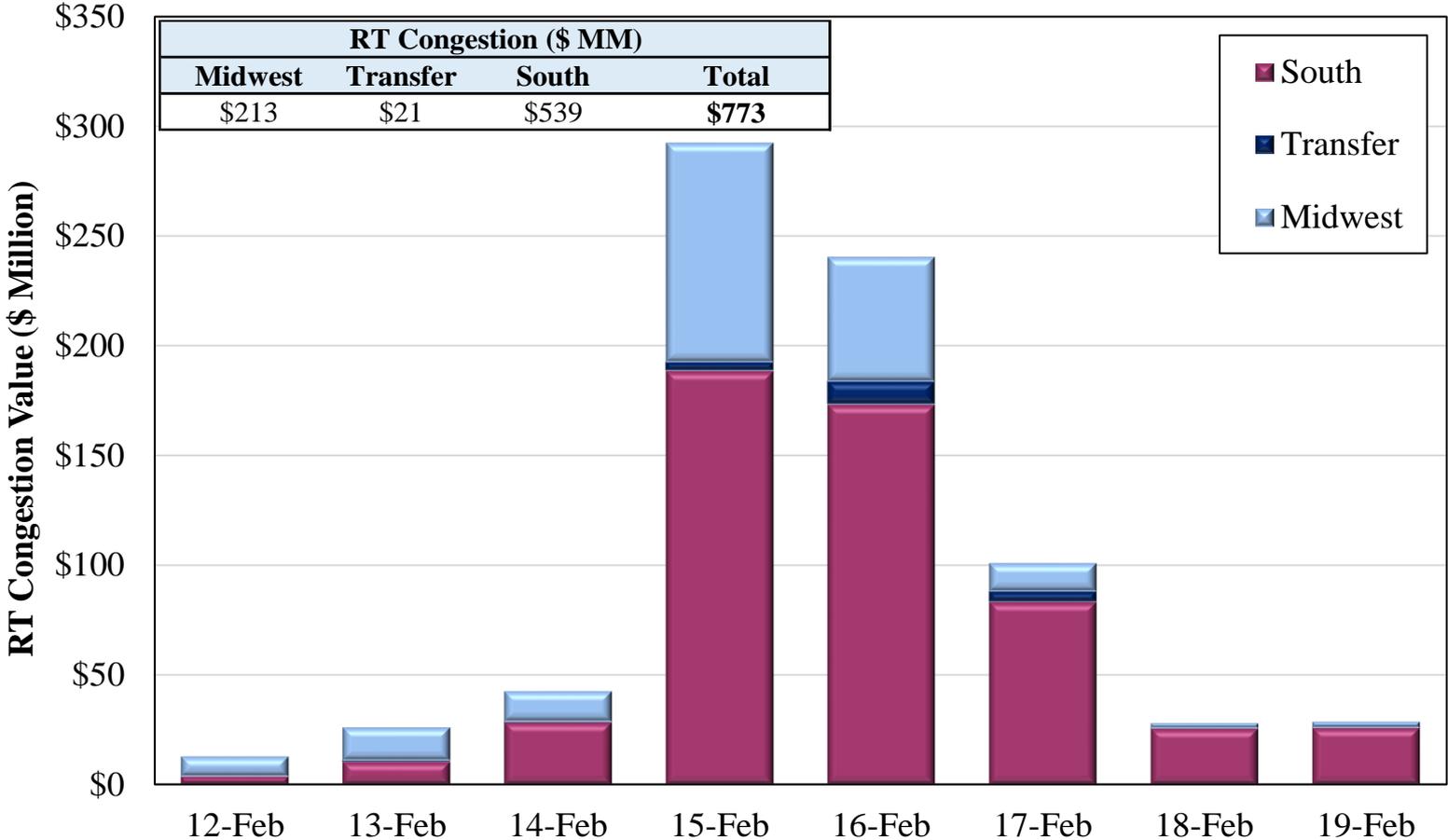
Daily Average and Low Temperatures February 14-20

	Hist. Avg.	February (Average)						
		14	15	16	17	18	19	20
Minneapolis	22	-11	-9	-1	5	11	11	12
Detroit	29	17	15	17	12	24	24	22
Indianapolis	33	11	13	12	14	19	15	22
Little Rock	45	18	12	15	18	25	23	25
New Orleans	57	41	34	29	43	43	40	44
Houston	58	34	22	26	36	36	38	46

	Hist. Avg.	February (Low Temperatures)						
		14	15	16	17	18	19	20
Minneapolis	14	-19	-17	-13	-2	7	4	0
Detroit	22	9	12	0	0	17	20	17
Indianapolis	24	3	10	4	2	13	8	13
Little Rock	35	14	8	4	15	20	11	10
New Orleans	48	38	29	25	32	37	33	35
Houston	49	28	18	15	33	32	26	32

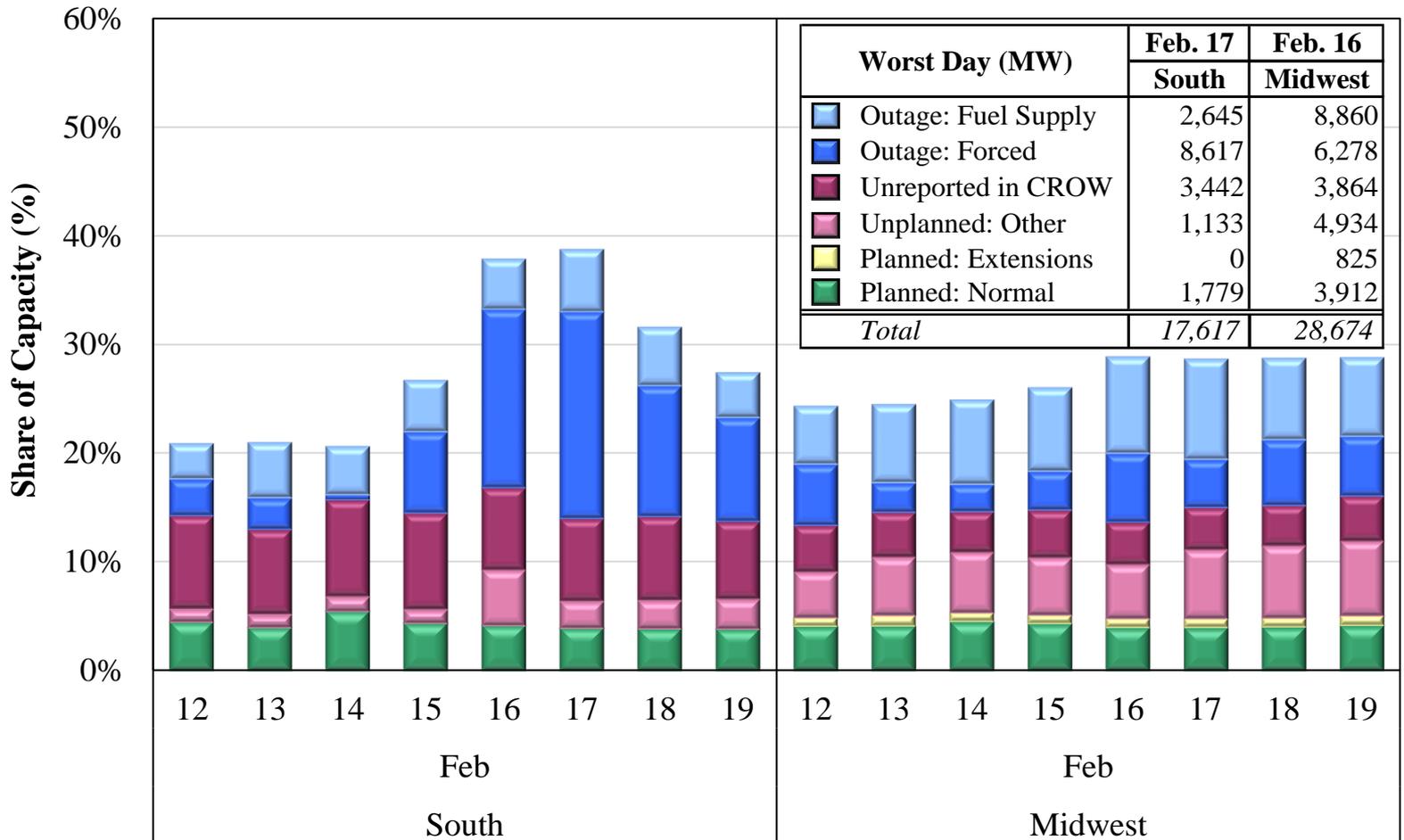


RT Congestion during Arctic Blast February 12-19

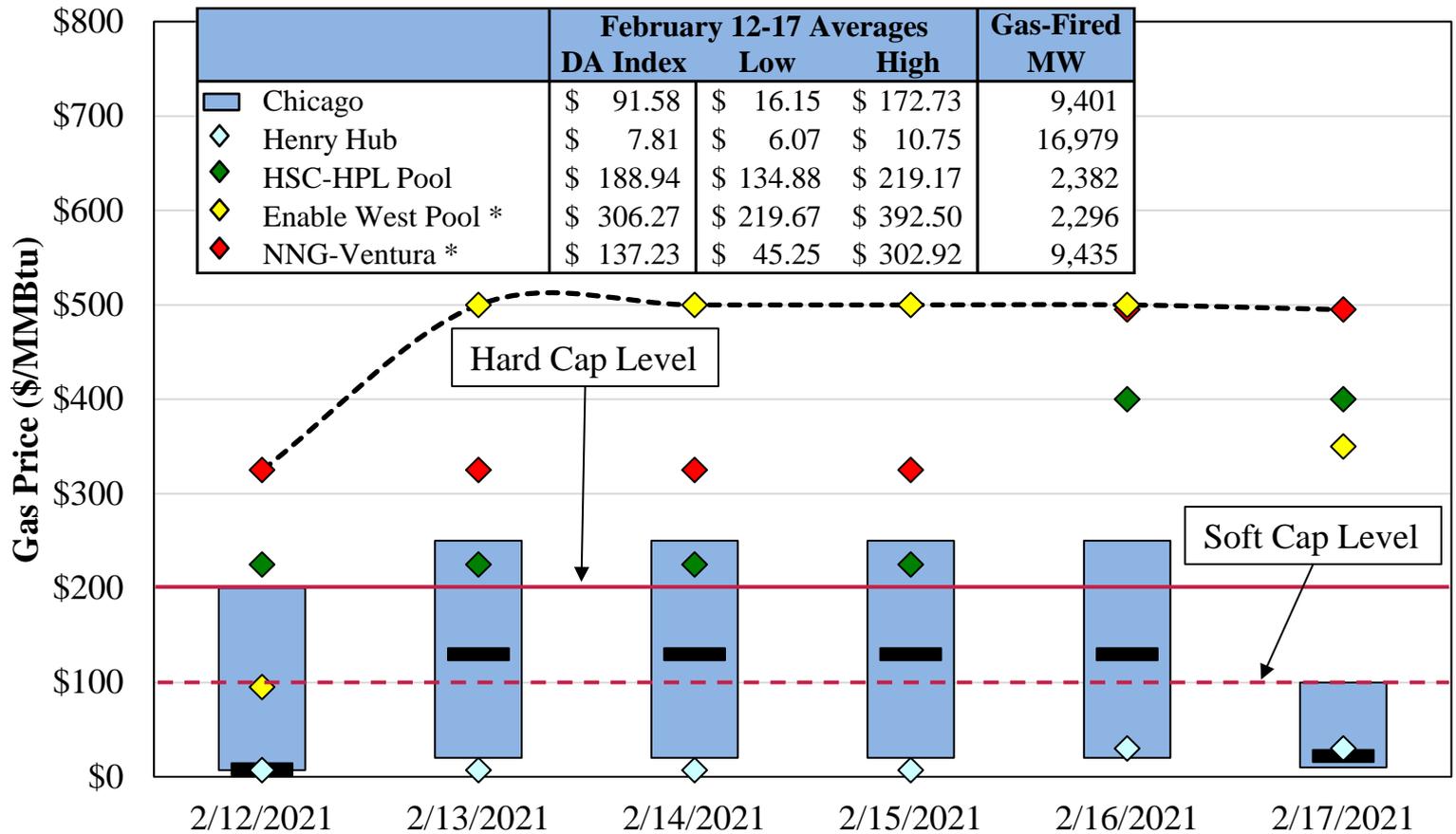




Outages in MISO South February 12-19



Natural Gas Prices at Different Delivery Points February 12-18

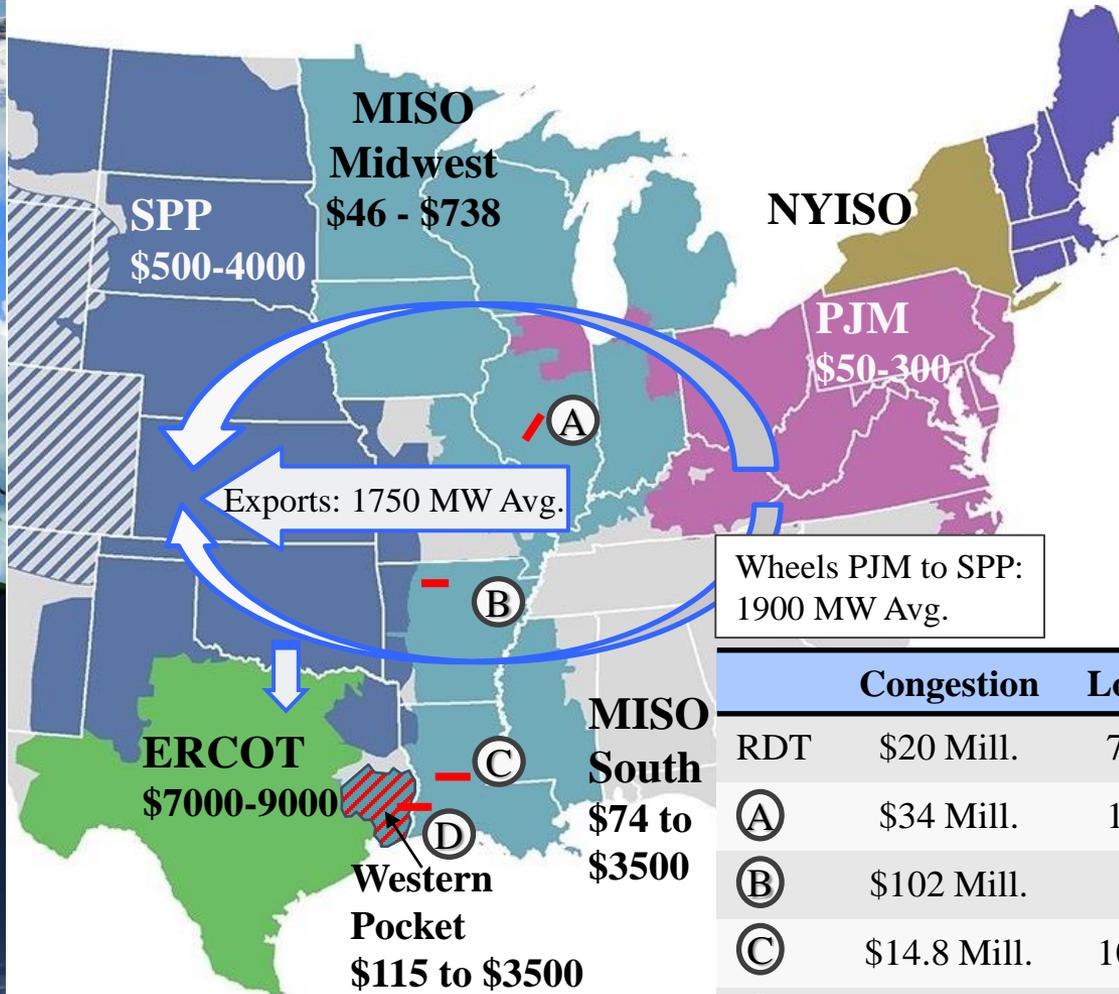


* Pipelines issuing Operational Flow Orders



Market Dynamics and Outcomes

February 15-16

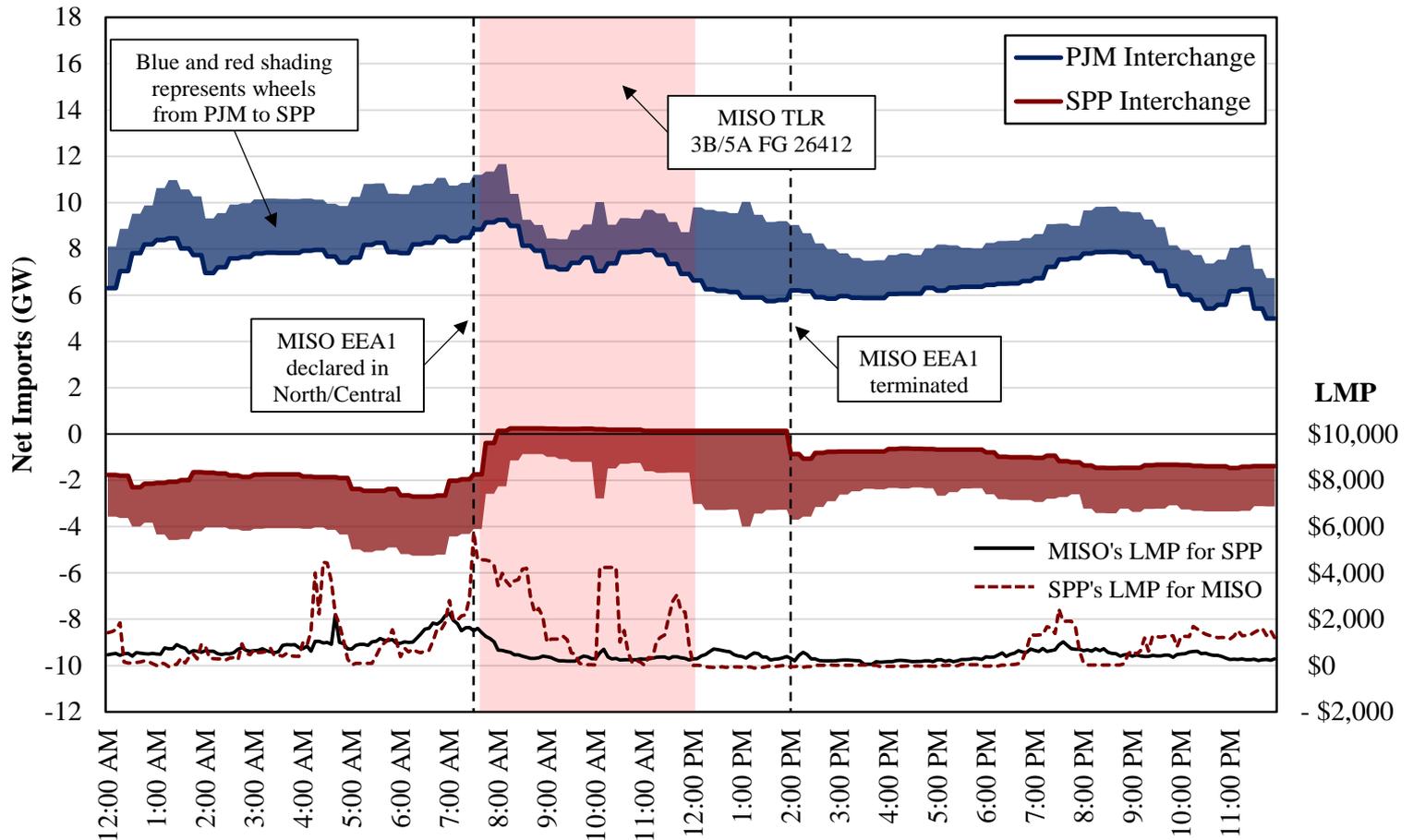


- Large power flows were scheduled into SPP from both PJM and MISO.
- SPP was in shortage and shed load in many hours.
- They were a main cause of the LTEs and load shedding in the Midwest, South, on the RDT.
- LTE pricing was not efficient – did not reflect the lost load.

	Congestion	Load Shed	Date	Duration
RDT	\$20 Mill.	700 MW	16 th PM	2 Hours
(A)	\$34 Mill.	130 MW	16 th AM	7 Hours
(B)	\$102 Mill.			
(C)	\$14.8 Mill.	1000 MW	16 th AM	4 Hours
(D)	\$59 Mill.	300-800	15-16 th	32 Hrs.

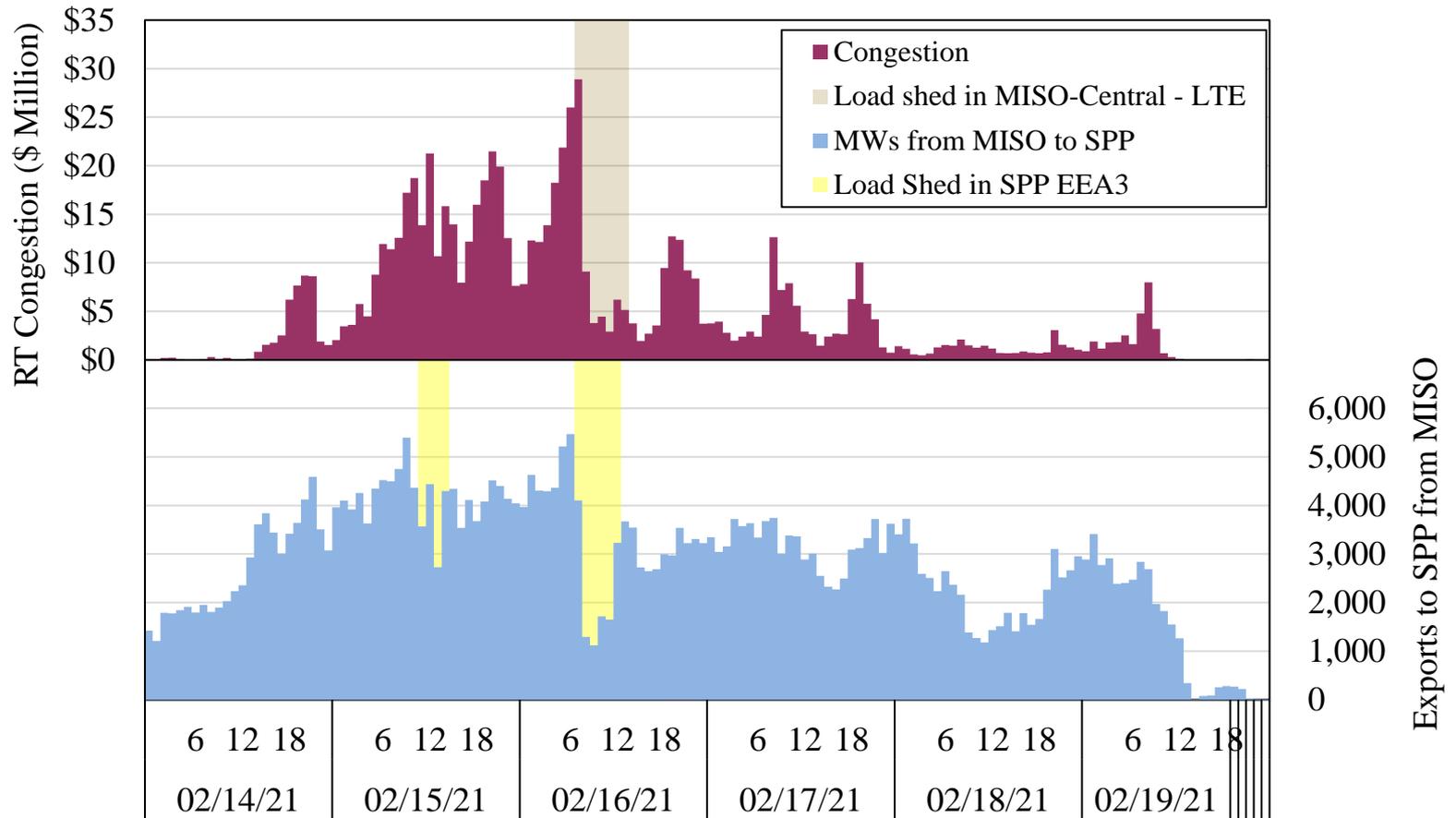
Map values incl Feb 15-16. Congestion values incl Feb 14-18

PJM and SPP Net Scheduled Interchange February 16, 2021



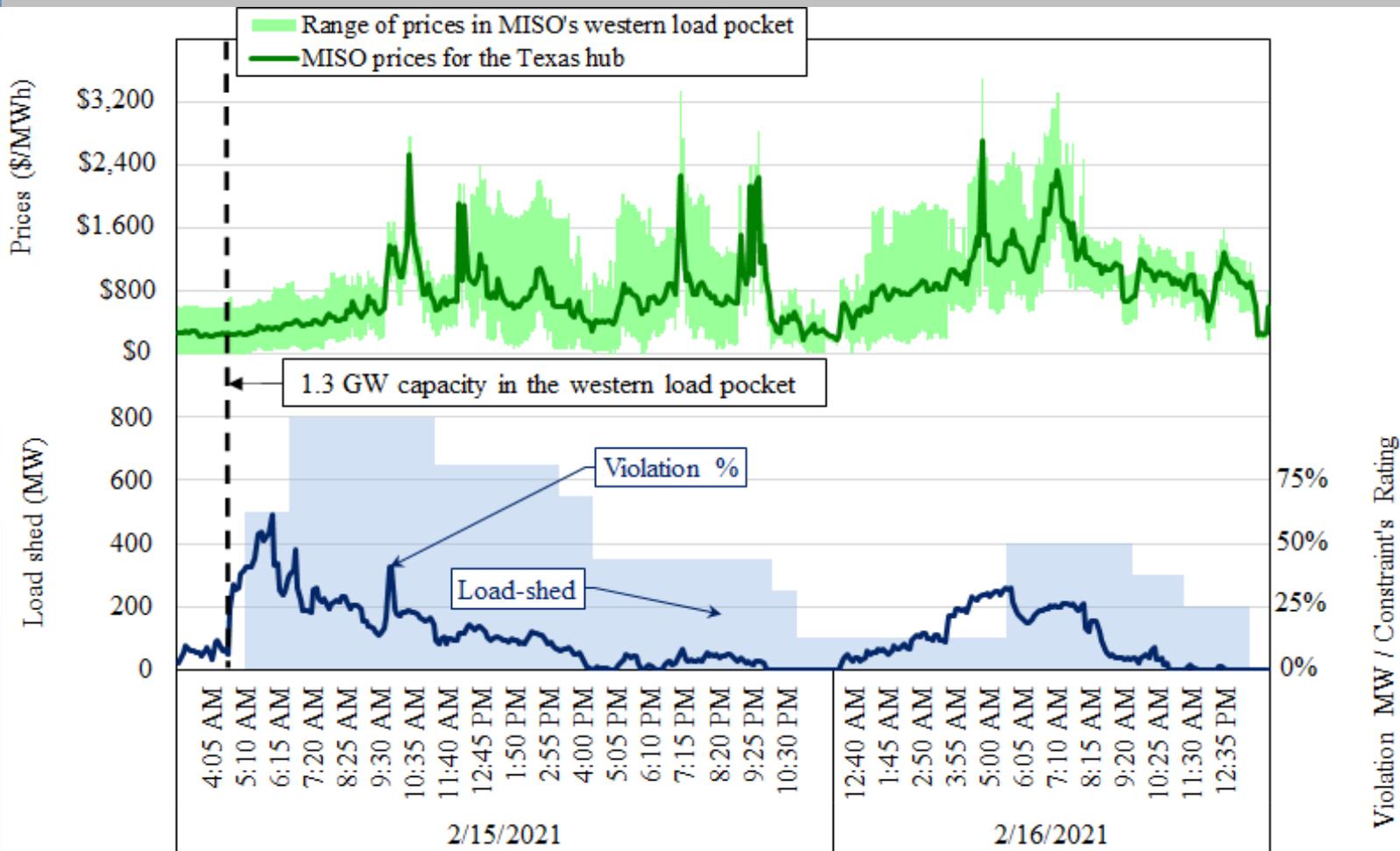


Transactions to SPP and Congestion February 14-19

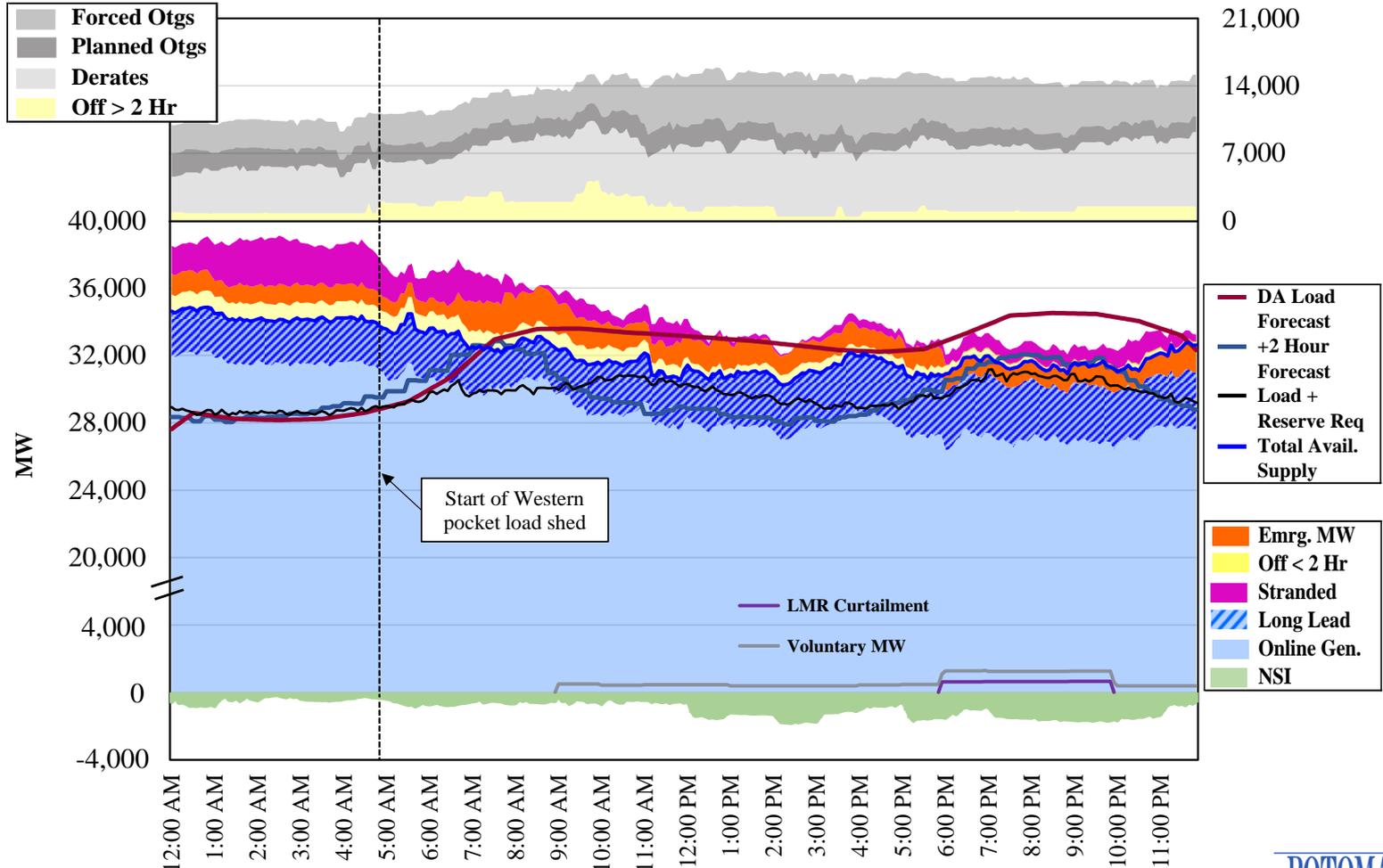




Load shed in Western Load Pocket February 15-16, 2021

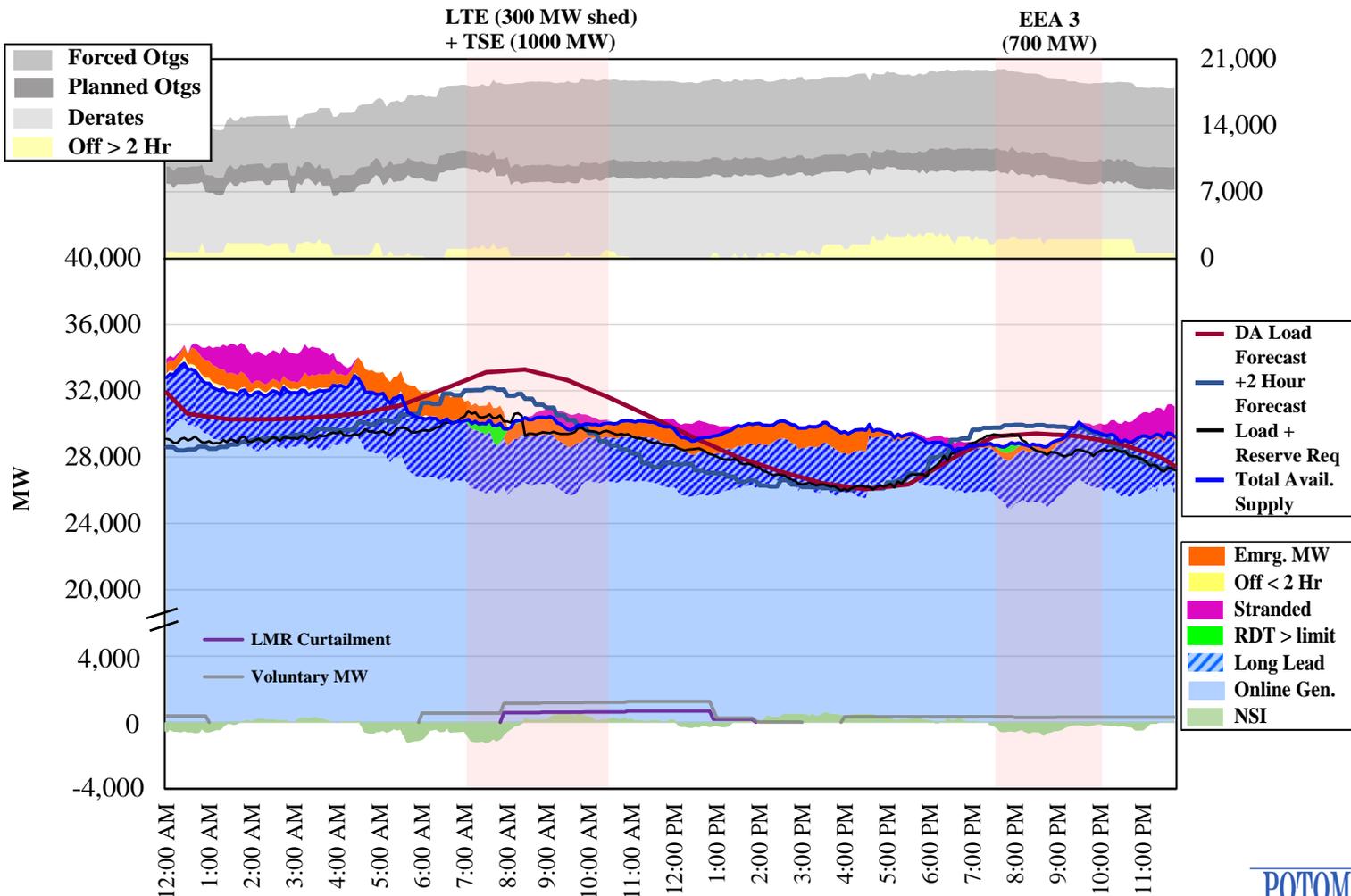


Capacity Balance MISO South February 15, 2021



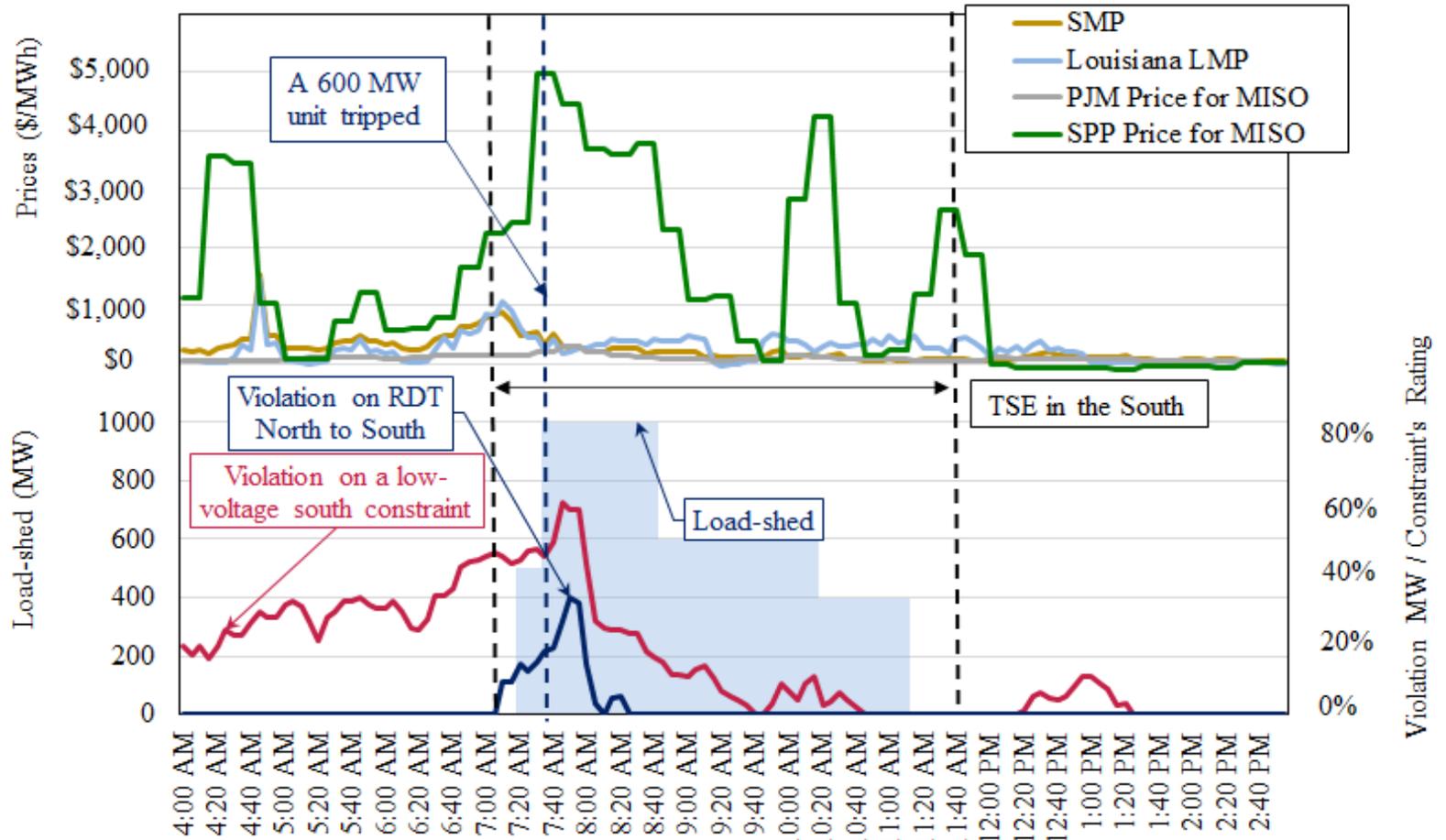


Capacity Balance MISO South February 16, 2021

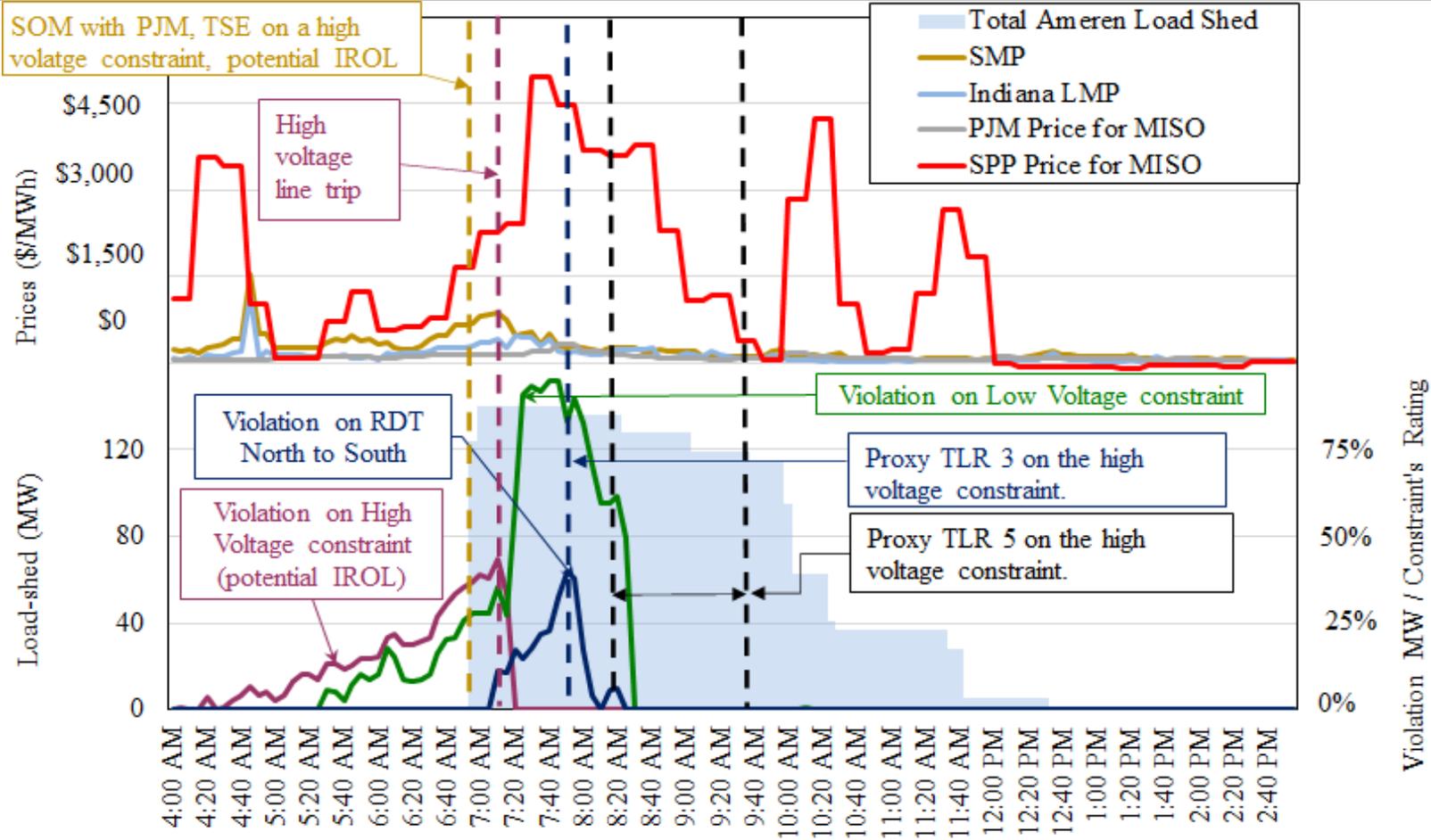




TSE Load Shed in MISO South February 16, 2021



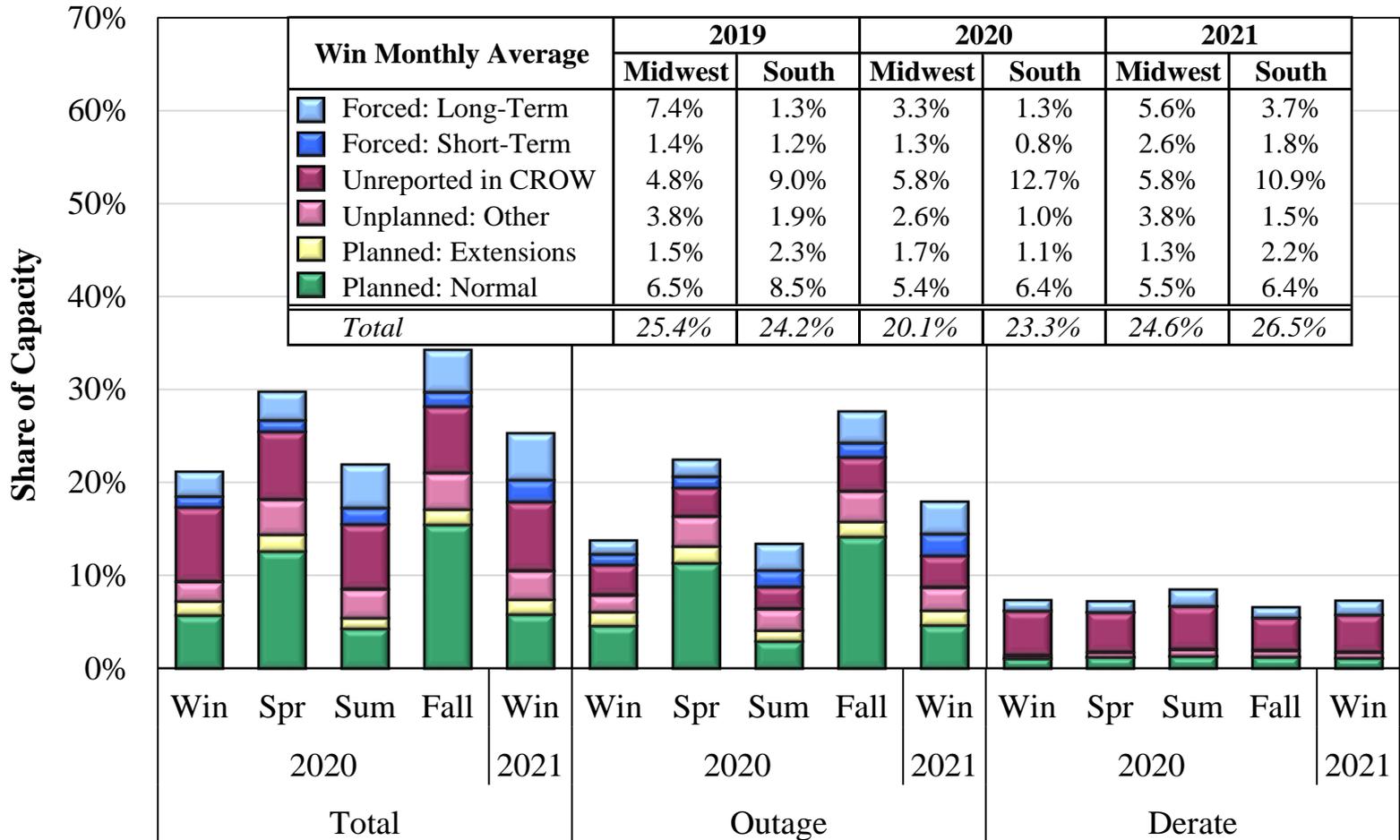
TSE and Load shed in Ameren February 16, 2021





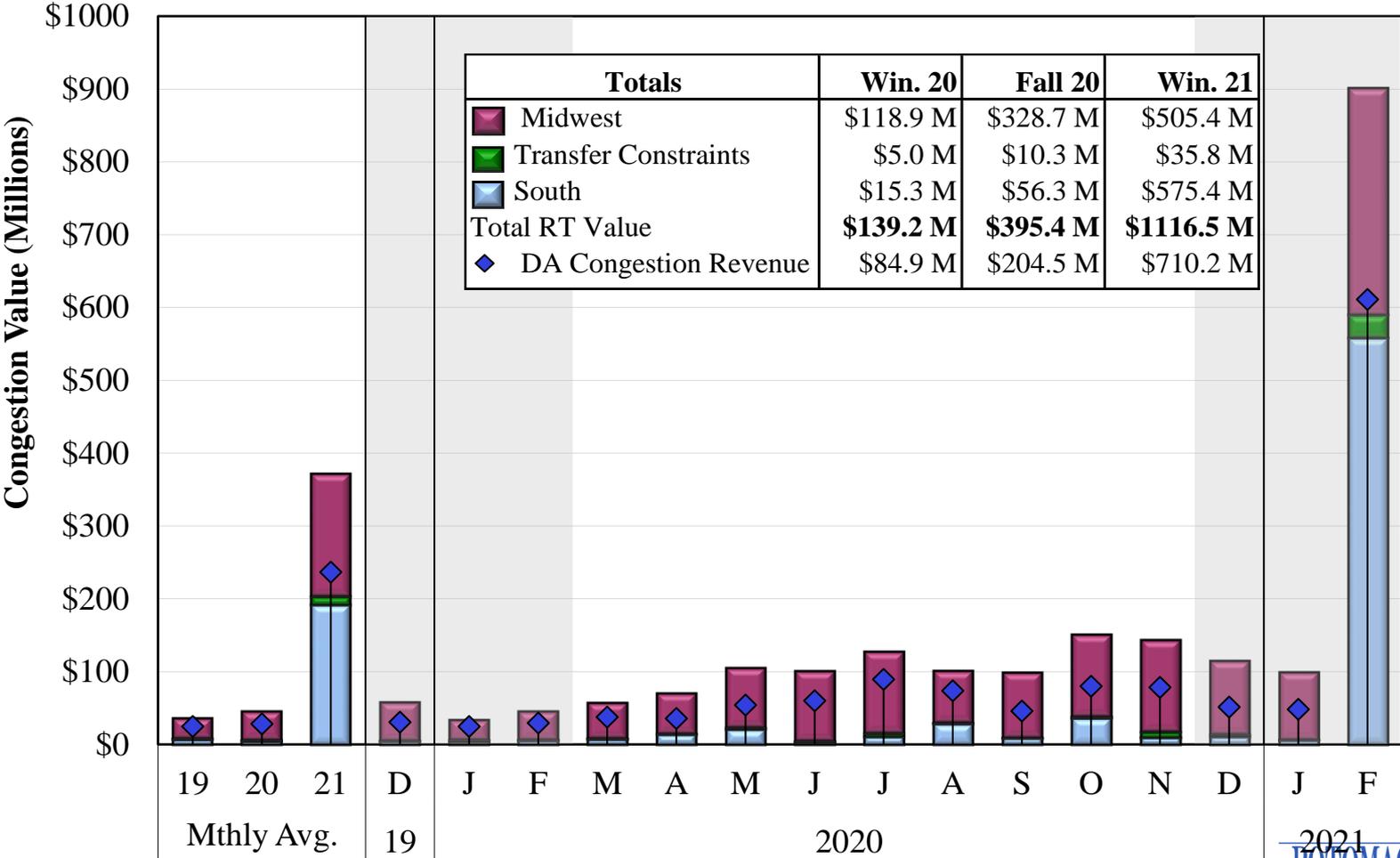
Generation Outages and Deratings

2020-2021



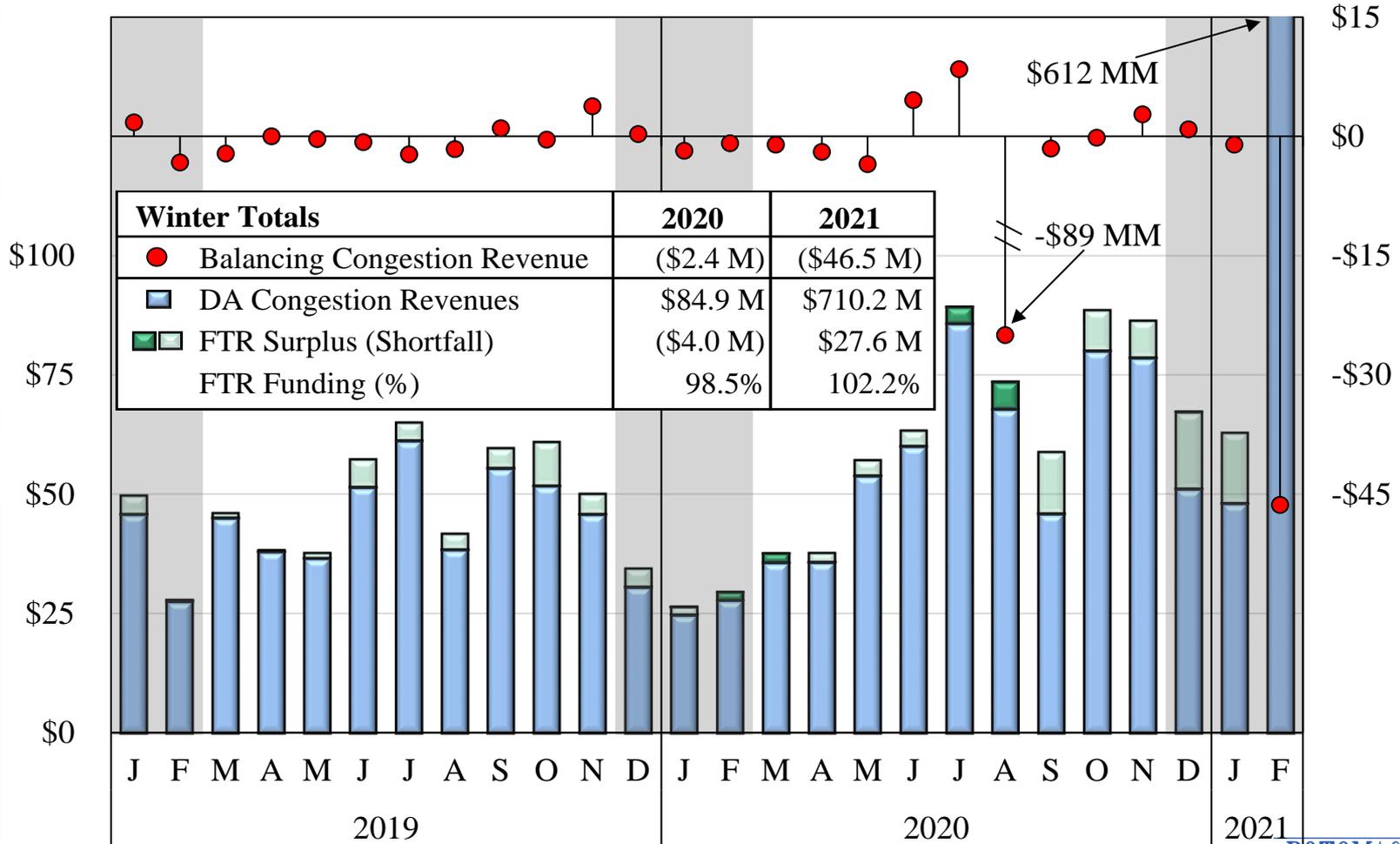


Value of Real-Time Congestion Winter 2020-2021

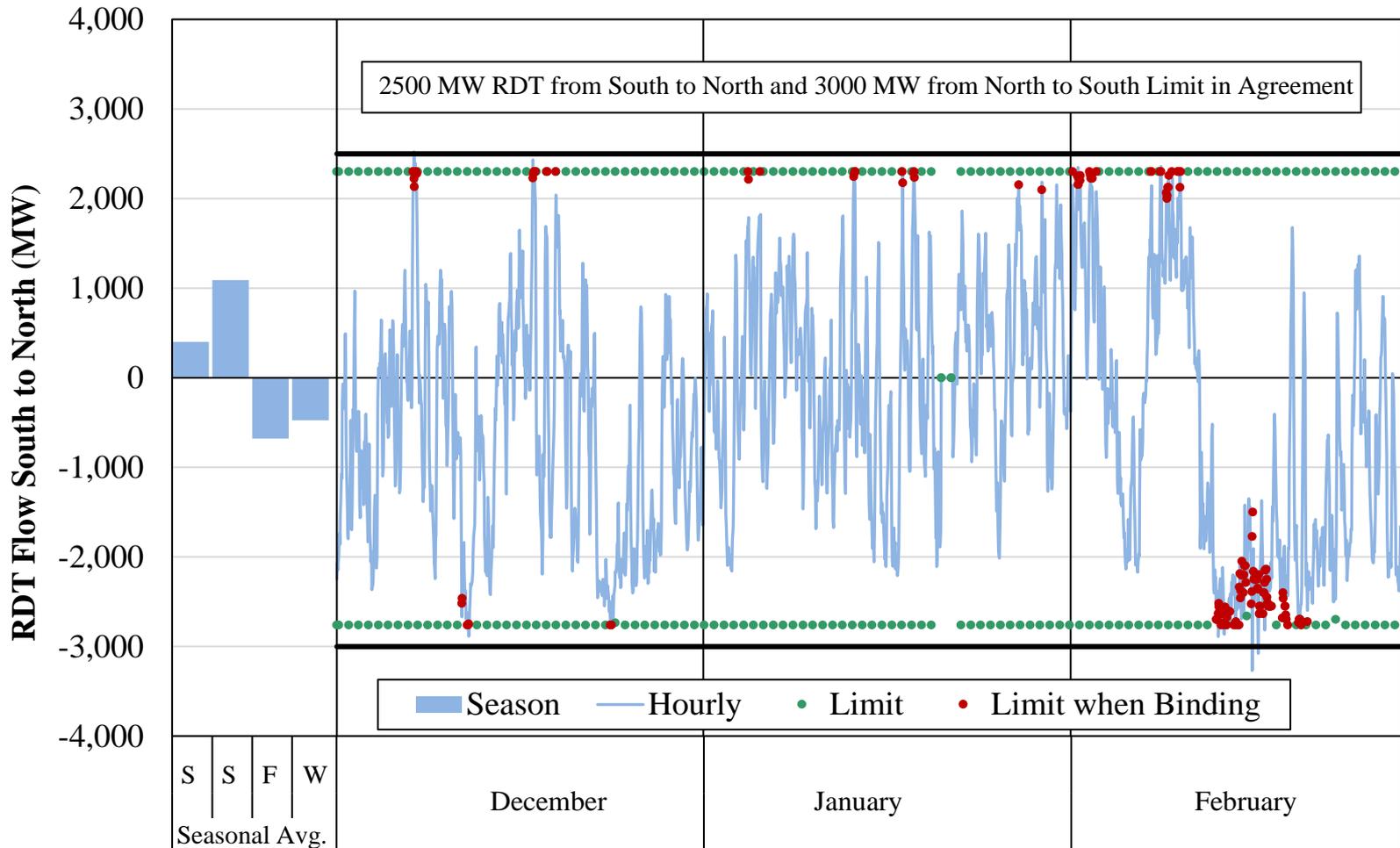




Day-Ahead Congestion, Balancing Congestion and FTR Underfunding

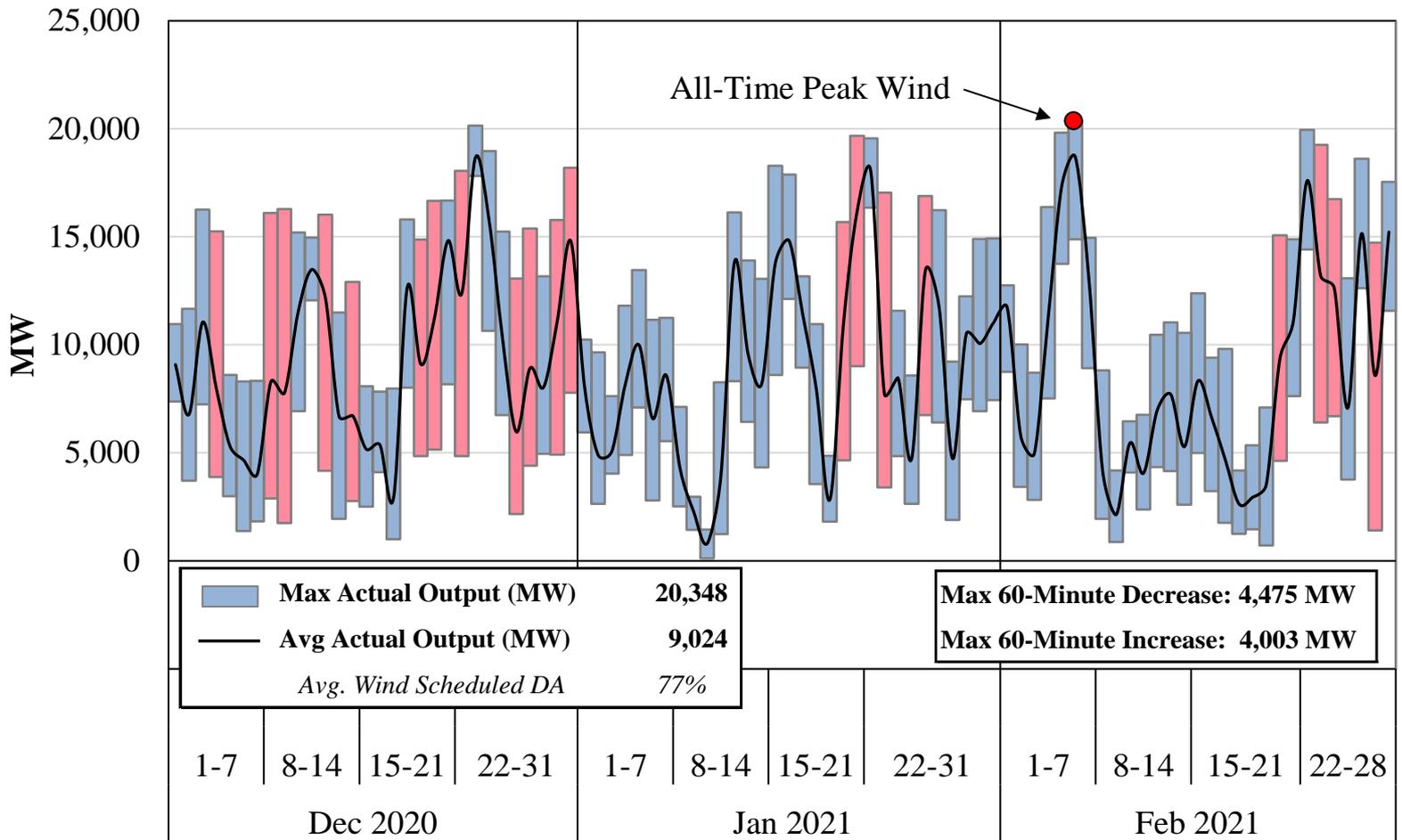


Real-Time Hourly Inter-Regional Flows Winter 2021



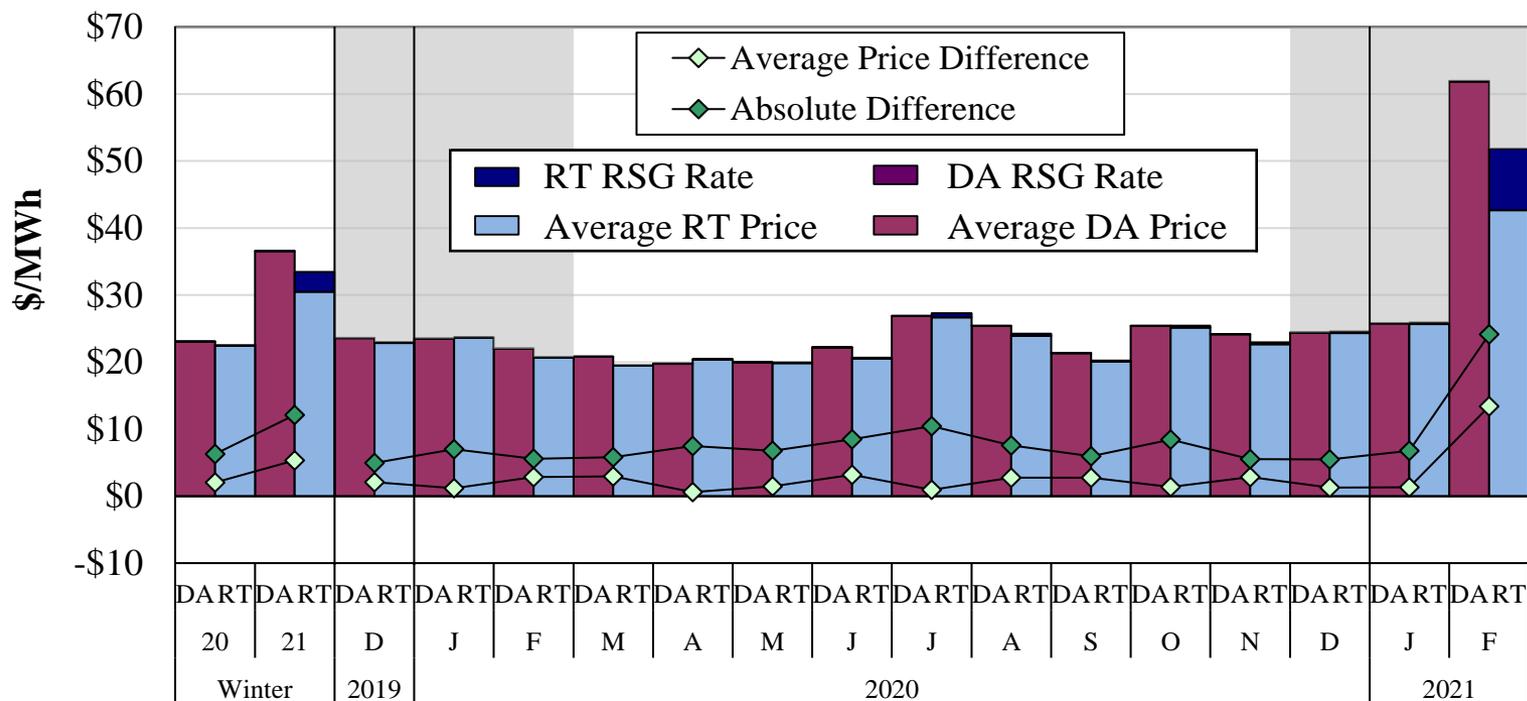


Wind Output in Real-Time Daily Range and Average





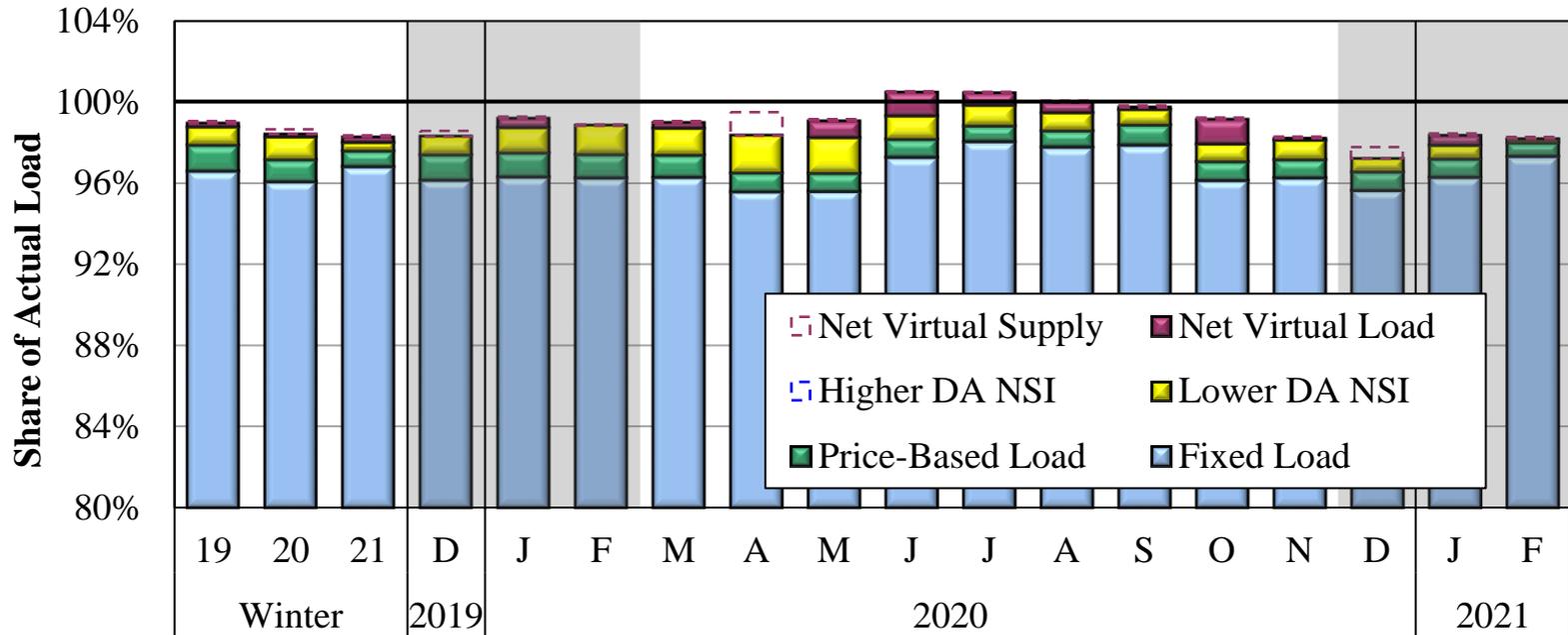
Day-Ahead and Real-Time Price Convergence Winter 2020-2021



Average DA-RT Price Difference Including RSG (% of Real-Time Price)

Indiana Hub	3	6	3	-1	6	7	-3	0	8	-2	5	6	0	5	-1	0	20
Michigan Hub	2	3	3	-2	6	7	-6	4	3	-5	3	6	-2	5	-1	0	11
Minnesota Hub	3	-1	5	-4	7	3	1	0	-5	-3	1	0	-4	-3	-7	-1	4
Arkansas Hub	3	-4	4	0	4	6	5	6	6	-7	2	3	-5	0	1	3	-16
Texas Hub	4	-3	4	1	6	10	5	13	7	2	3	6	9	4	1	0	-11
Louisiana Hub	0	-4	2	0	-2	12	4	5	6	1	0	8	-5	1	3	1	-15

Day-Ahead Peak Hour Load Scheduling Winter 2020-2021

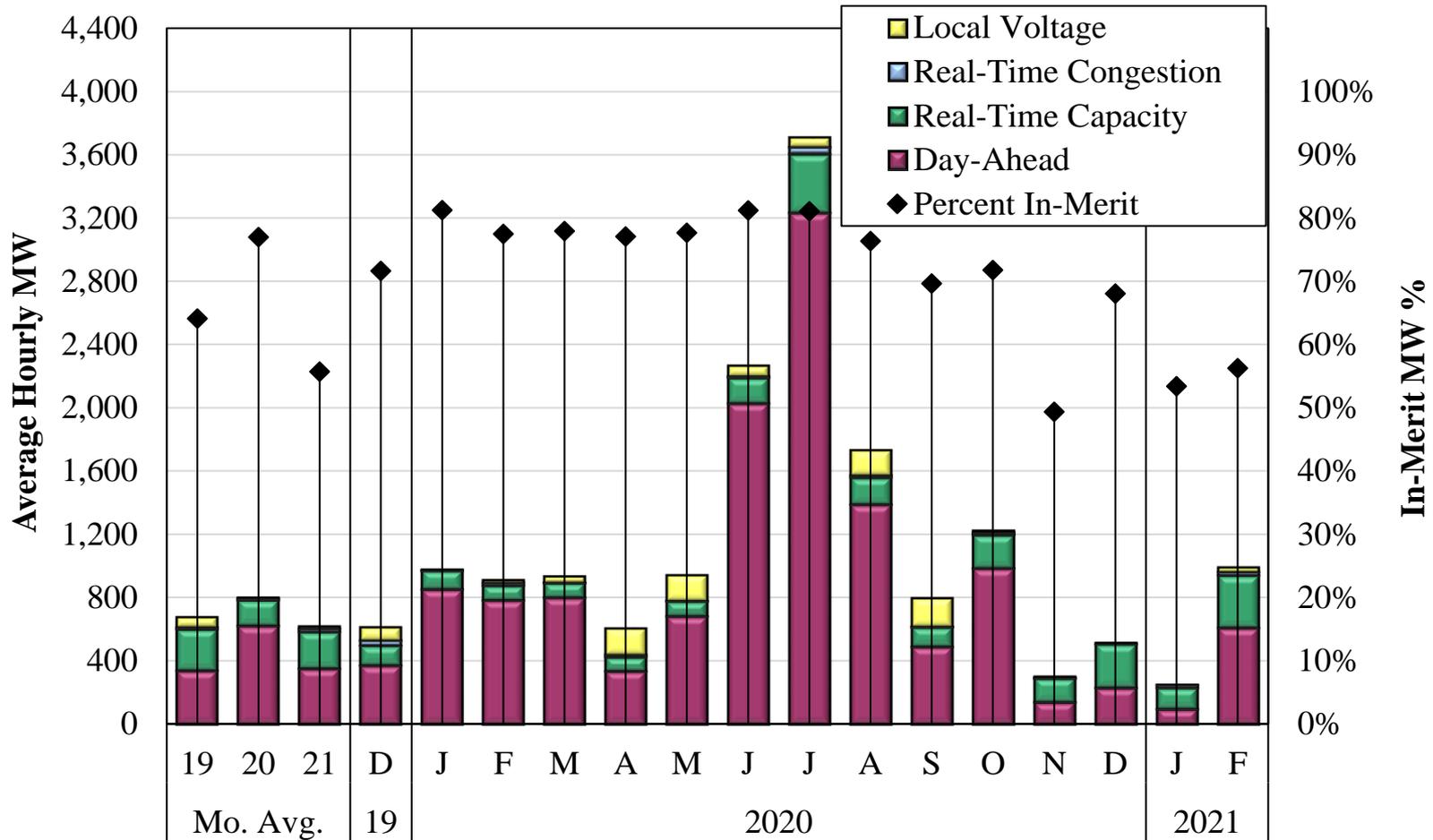


Share of Actual Load (%)

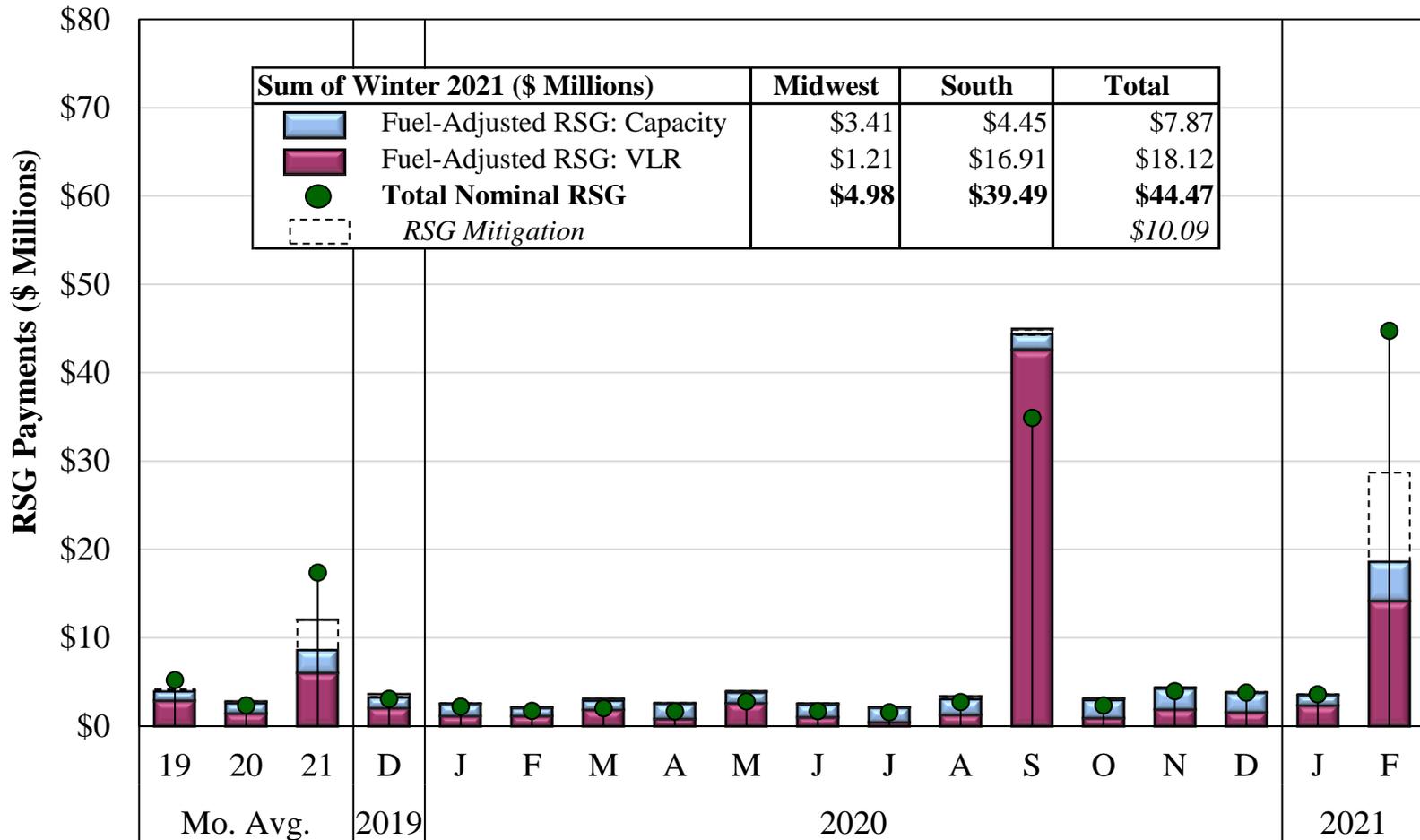
All Hours	98.9	98.7	98.5	98.9	98.5	98.2	99.5	99.0	98.9	99.0	99.5	100.4	101.5	101.0	99.7	98.8	98.4	97.8	98.5	98.5
Peak Hours Midwest	98.5	98.4	97.9	99.0	98.2	98.5	99.6	98.9	100.2	98.2	98.4	99.9	99.8	99.0	99.5	98.8	98.5	96.6	98.5	97.4
Peak Hours South	100.8	98.6	102.5	100.6	100.7	99.1	99.2	98.5	98.2	101.0	101.5	101.2	101.8	102.1	100.0	100.7	98.5	98.2	101.3	103.6



Peaking Resource Dispatch Winter 2020-2021

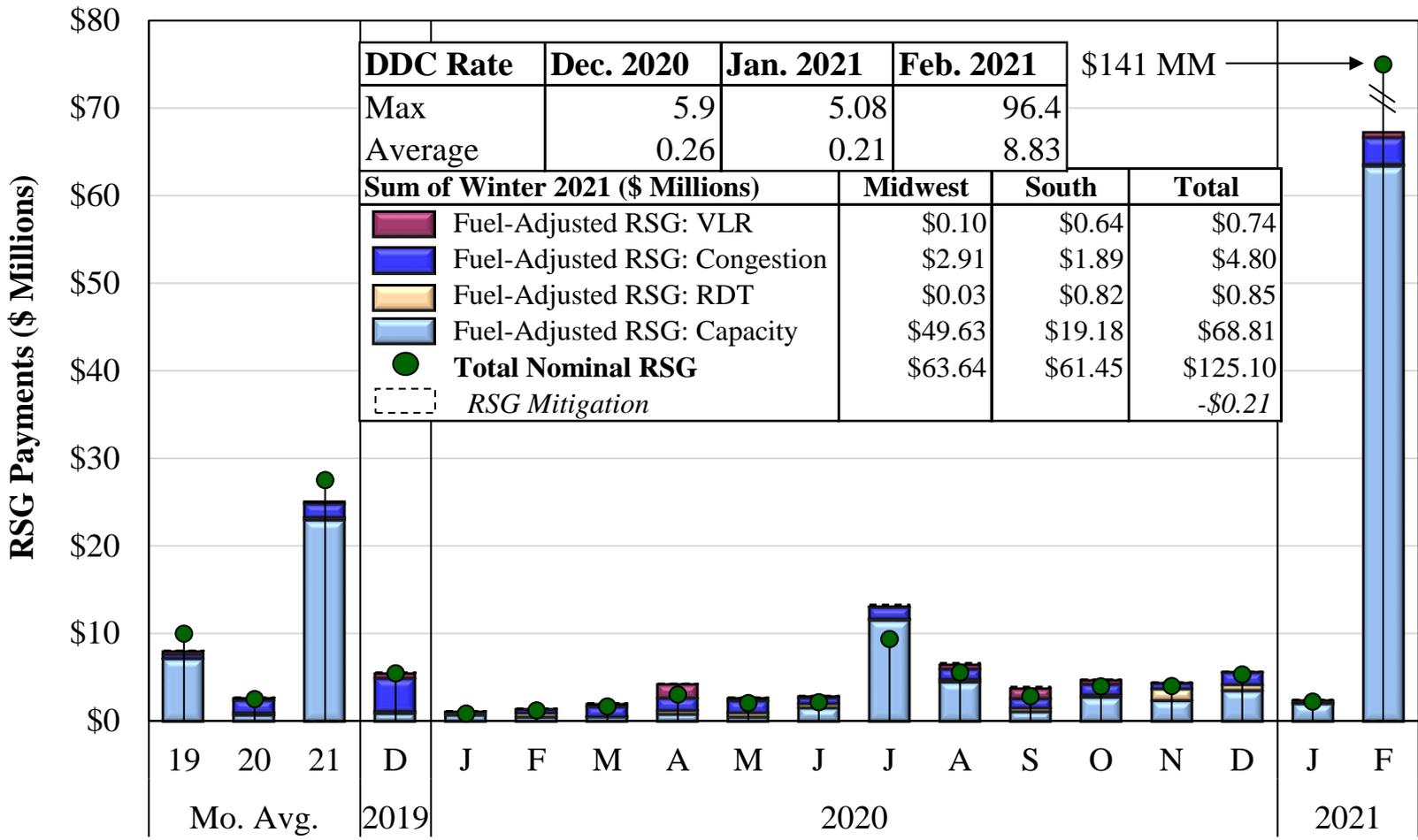


Day-Ahead RSG Payments Winter 2020-2021



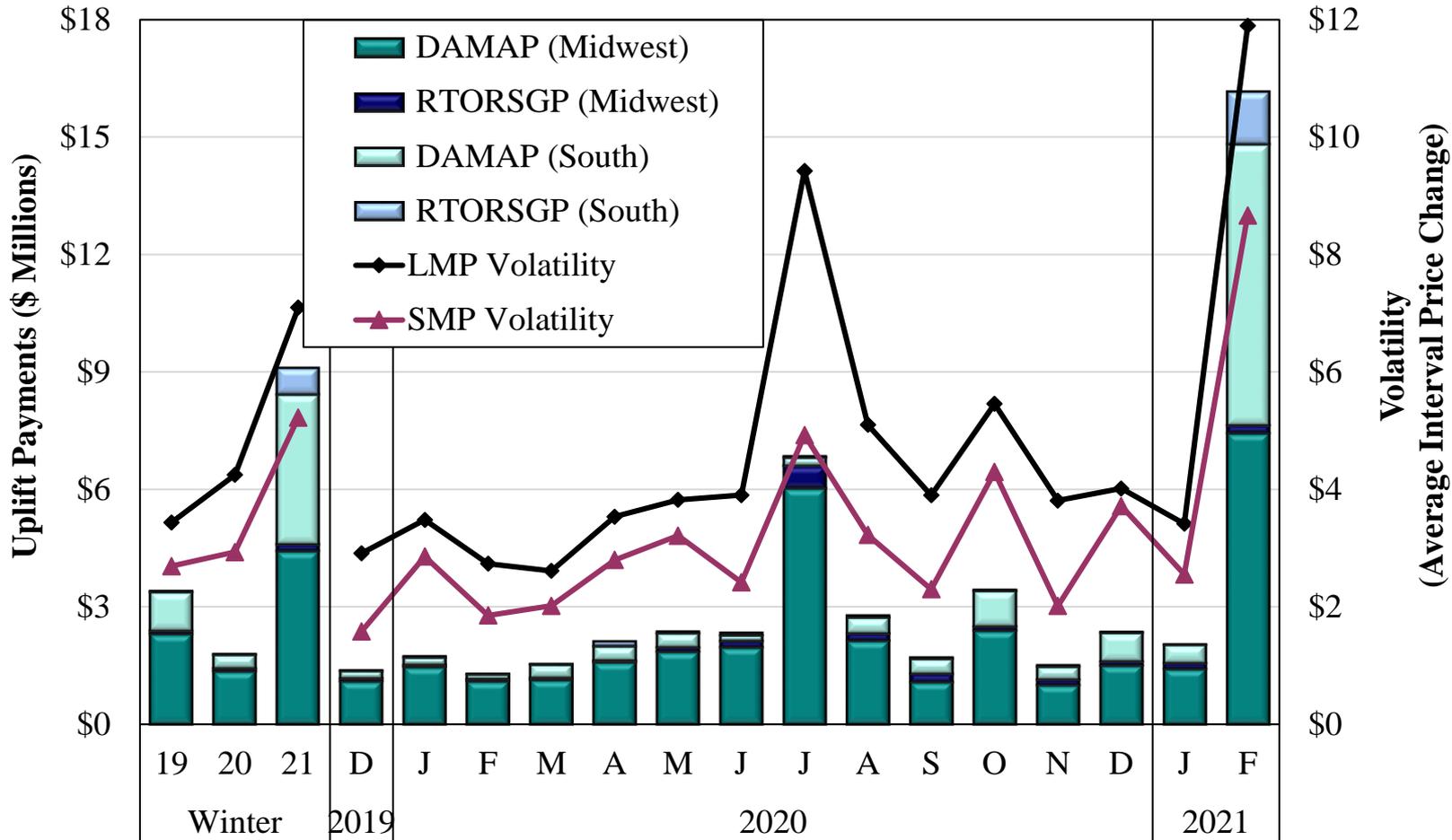


Real-Time RSG Payments Winter 2020-2021



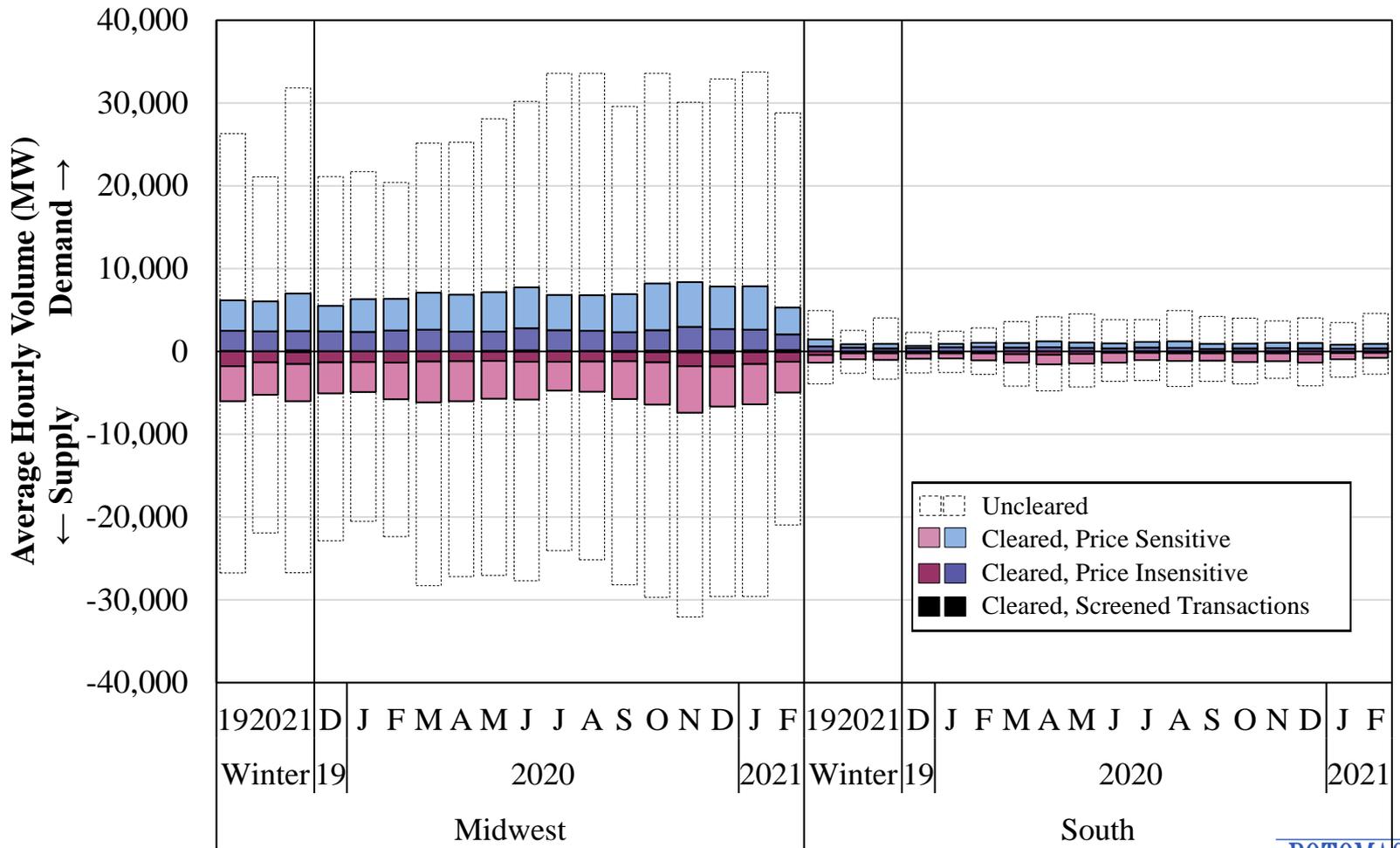


Price Volatility Make Whole Payments Winter 2020-2021



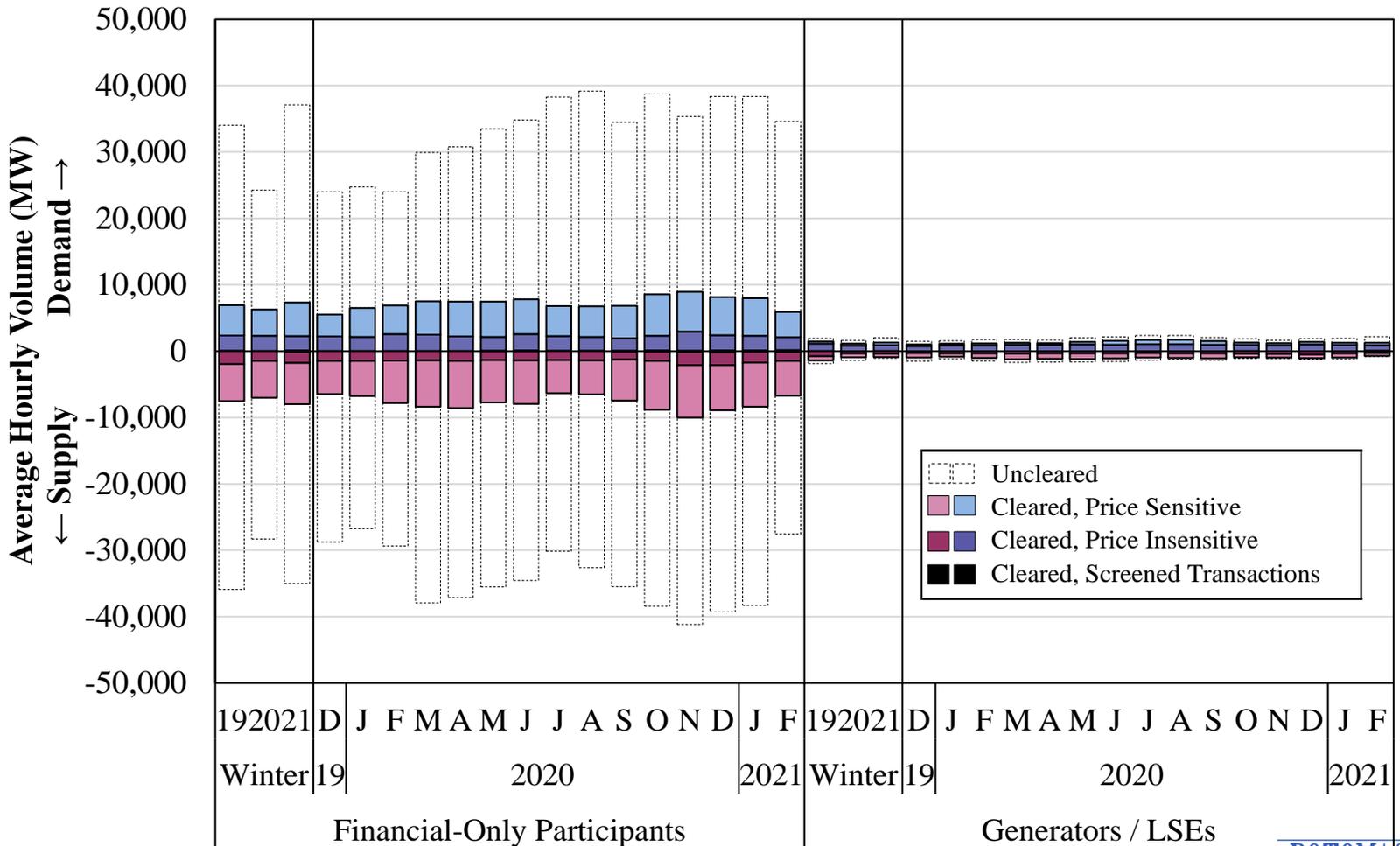


Virtual Load and Supply Winter 2020-2021



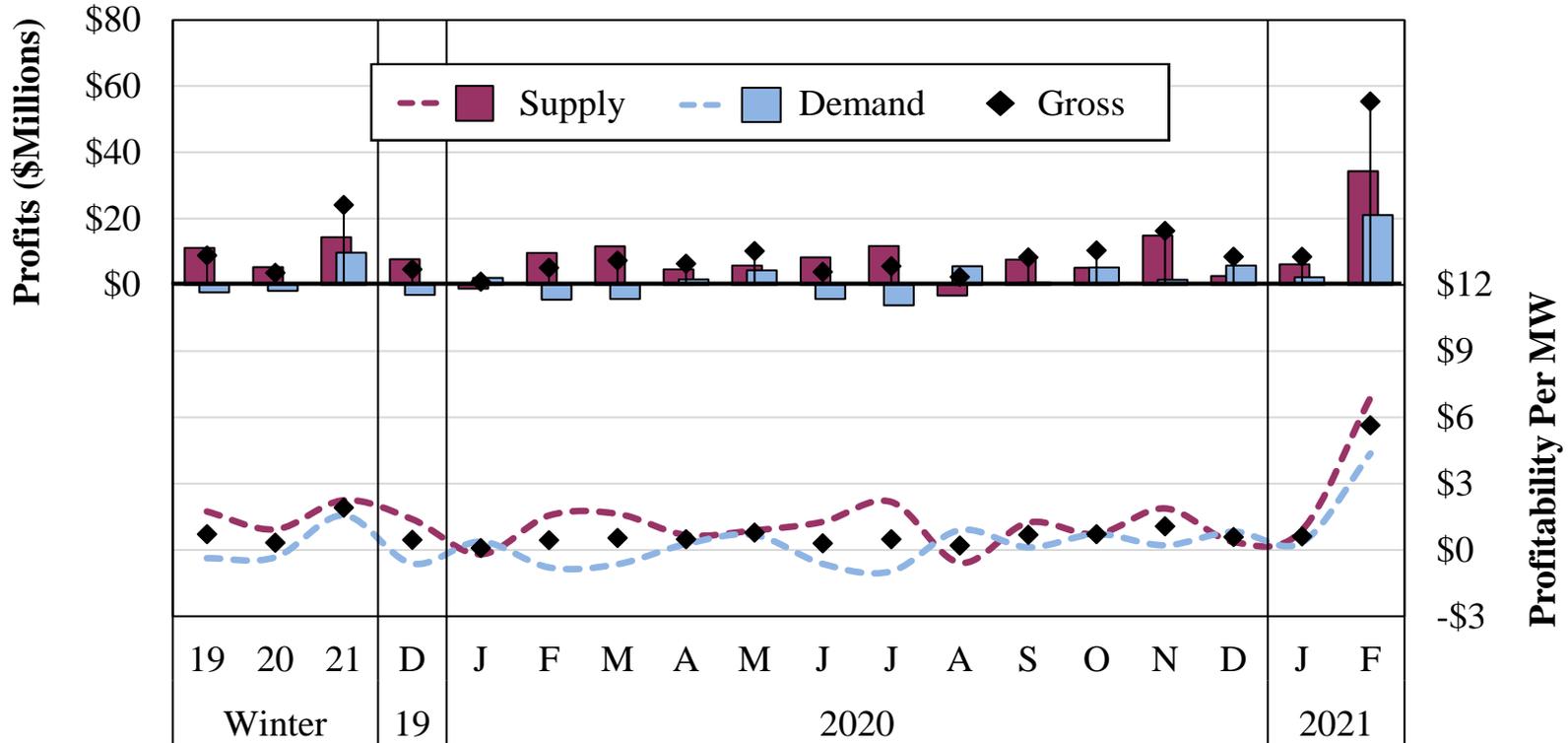


Virtual Load and Supply by Participant Type Winter 2020-2021





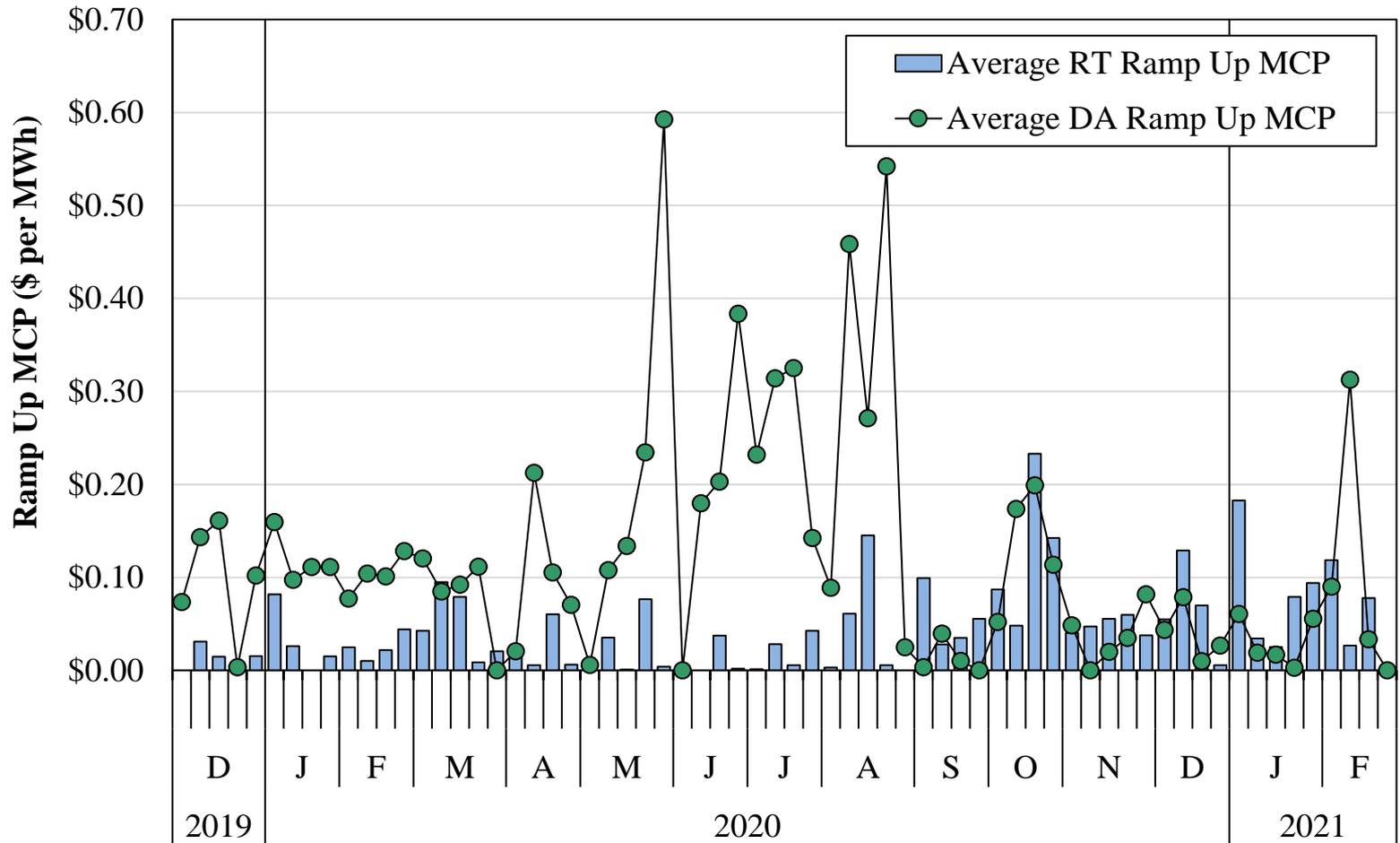
Virtual Profitability Winter 2020-2021



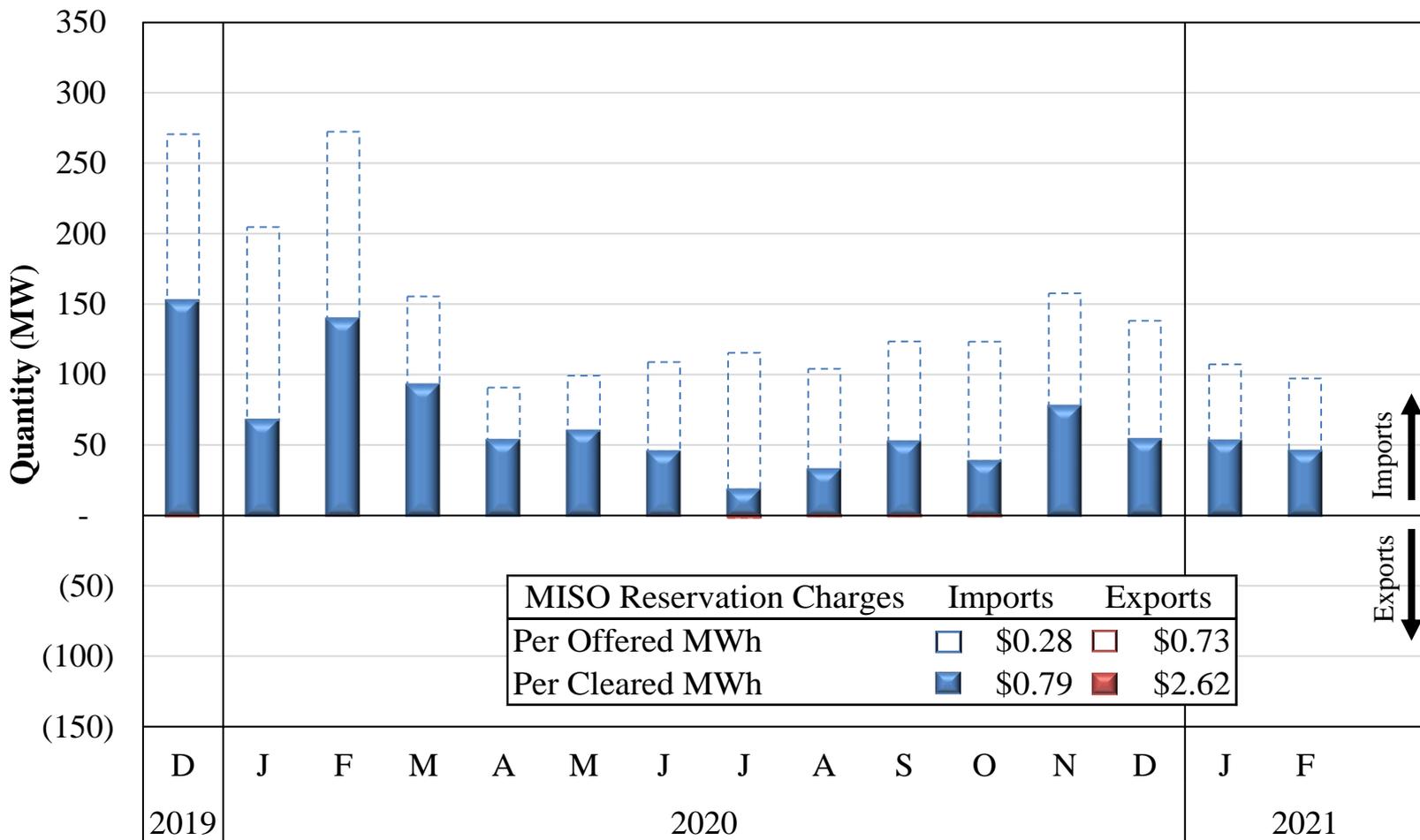
Percent Screened

Supply	0.2	0.1	1.5	0.1	0.2	0.1	0.2	0.2	0.4	0.5	0.3	0.3	0.9	1.0	1.3	1.7	1.0	1.8
Demand	1.0	0.5	2.0	0.7	0.4	0.5	0.5	0.4	0.9	1.6	1.2	1.1	0.8	1.2	1.1	1.3	1.4	3.7
Total	0.6	0.3	1.7	0.4	0.3	0.3	0.4	0.3	0.6	1.0	0.8	0.7	0.9	1.1	1.2	1.5	1.2	2.7

Day-Ahead and Real-Time Ramp Up Price 2020-2021

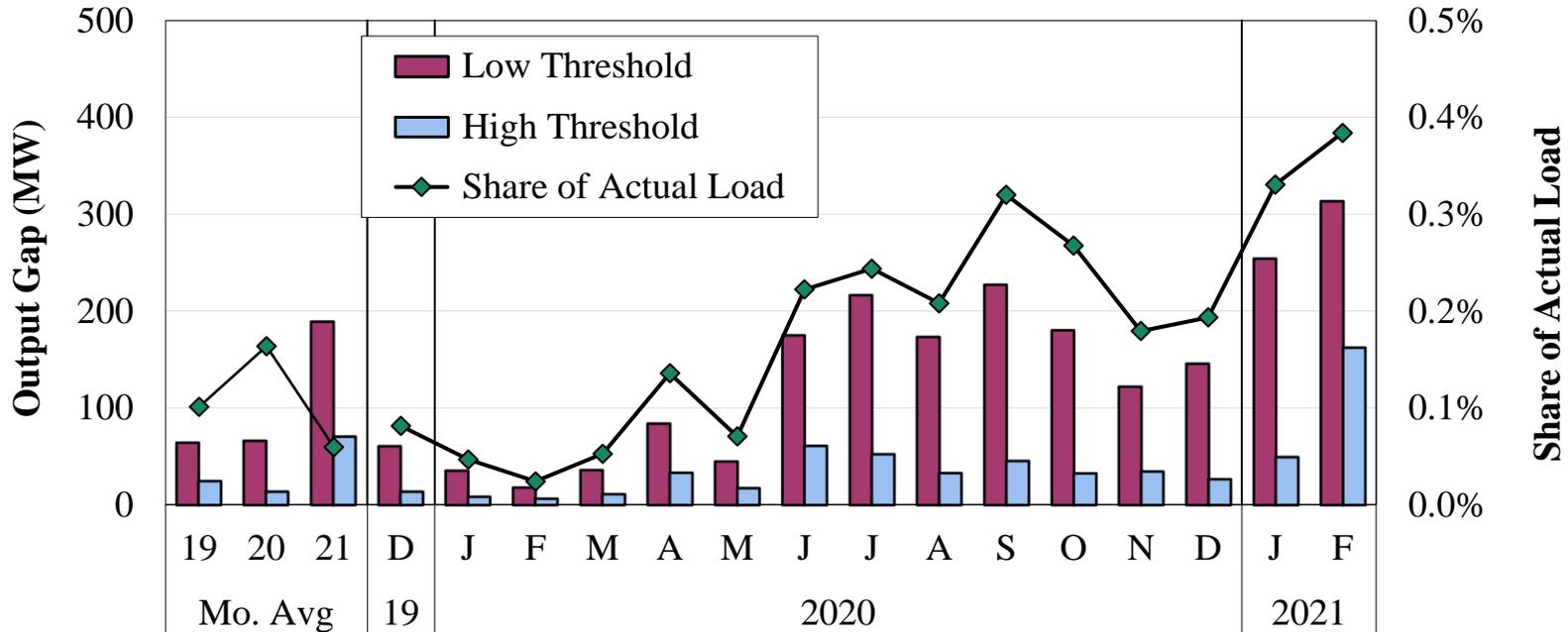


Coordinated Transaction Scheduling (CTS) Winter 2020-2021





Monthly Output Gap Winter 2020-2021



Low Threshold Results by Unit Status (MW)

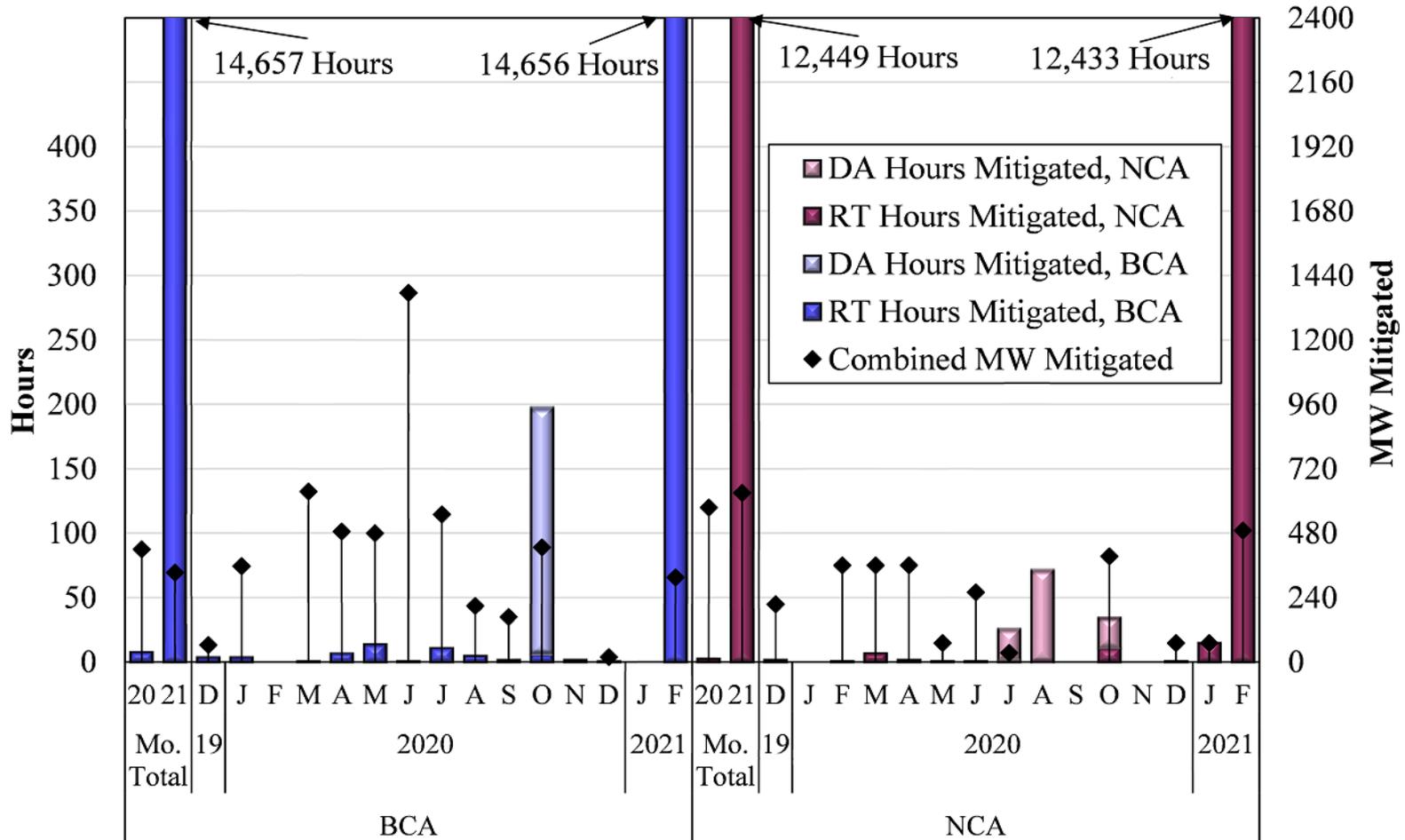
Offline	16	2	31	5	0	0	0	0	3	12	36	18	4	8	10	2	0	90
Online	50	36	207	55	36	18	36	84	42	163	180	156	223	172	112	144	254	223

High Threshold Results by Unit Status (MW)

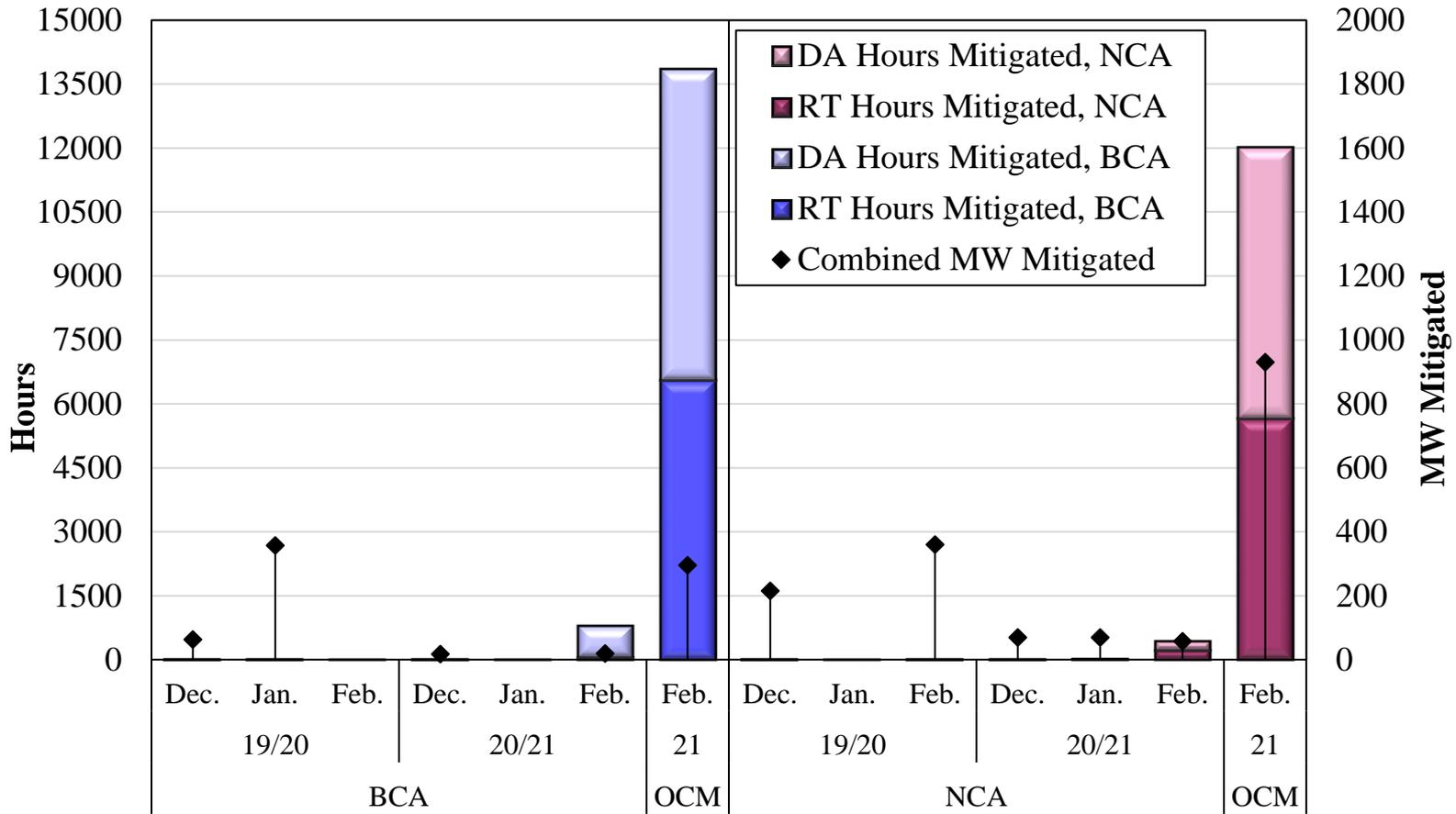
Offline	13	2	24	5	0	0	0	0	3	11	31	16	4	7	7	2	0	70
Online	17	8	55	9	9	7	11	33	15	50	21	17	41	25	28	25	49	91



Day-Ahead And Real-Time Energy Mitigation Winter 2020-2021

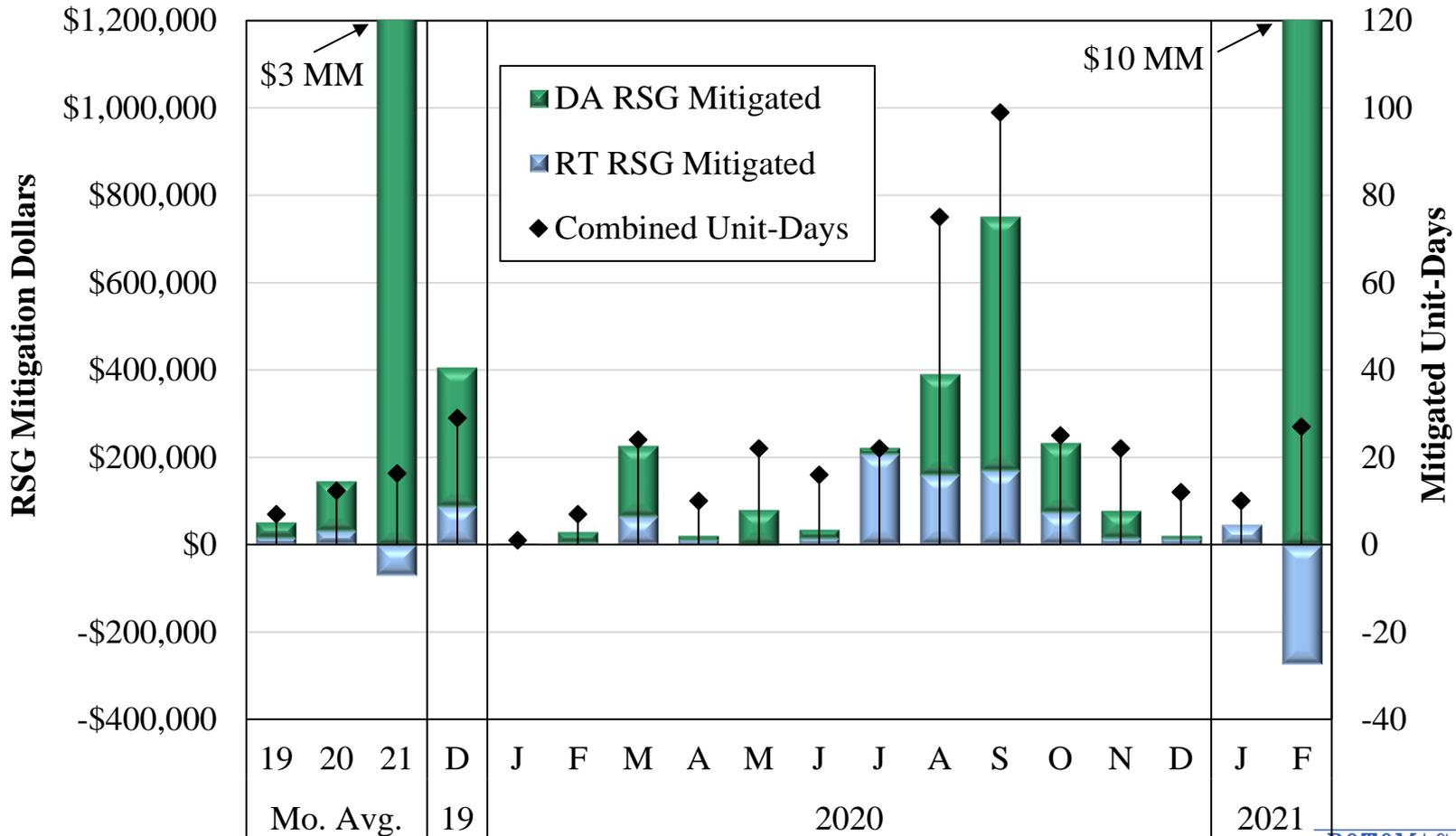


Day-Ahead And Real-Time Energy Mitigation Winter 2020 and 2021

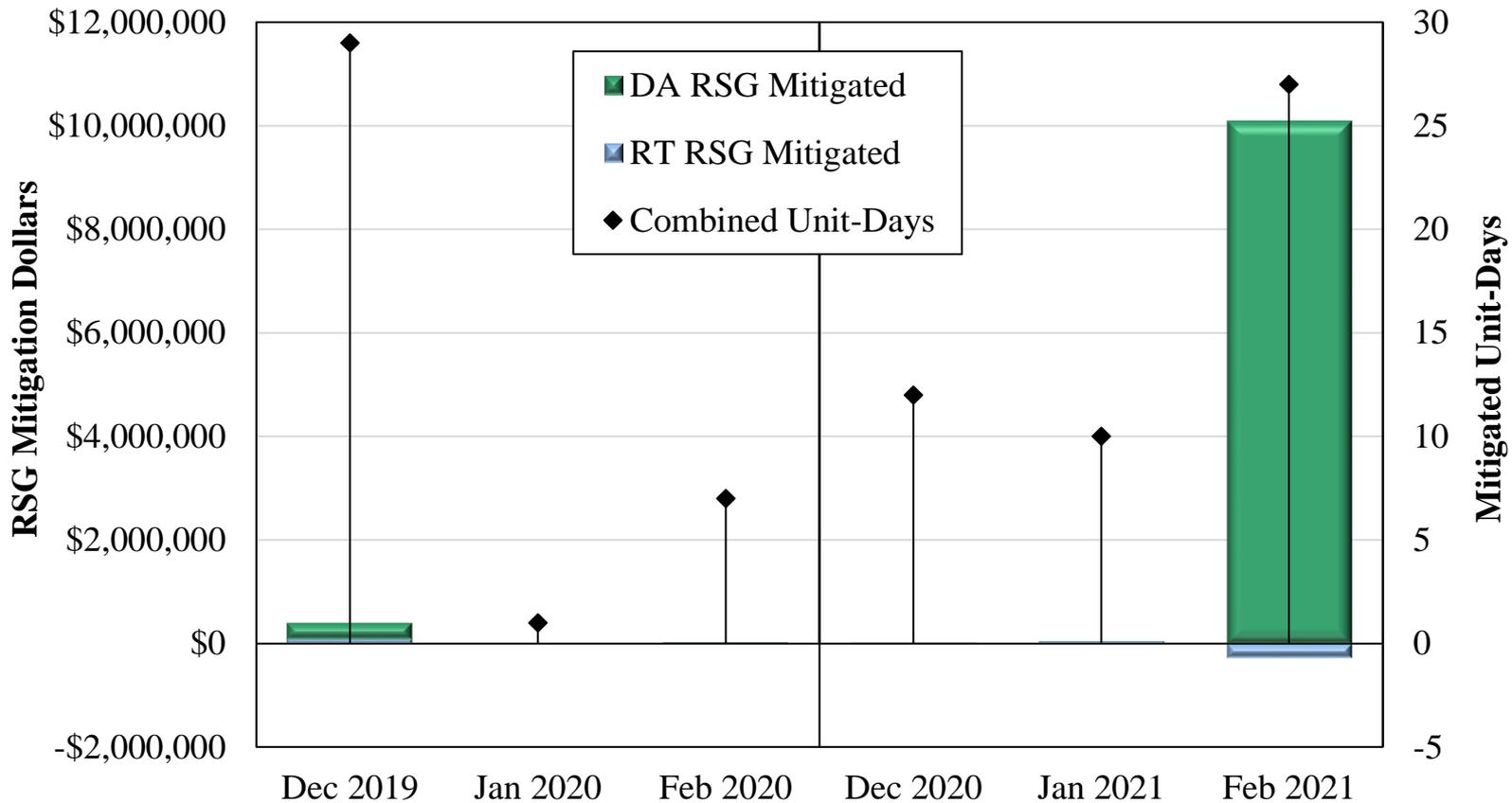


OCM: Offer Cap Mitigation

Day-Ahead and Real-Time RSG Mitigation Winter 2020-2021



Day-Ahead and Real-Time RSG Mitigation Winter 2020 and 2021



List of Acronyms

- AAR Ambient-Adjusted Ratings
- AMP Automated Mitigation Procedures
- BCA Broad Constrained Area
- CDD Cooling Degree Days
- CMC Constraint Management Charge
- CTS Coordinated Transaction Scheduling
- DAMAP Day-Ahead Margin Assurance Payment
- DDC Day-Ahead Deviation & Headroom Charge
- DIR Dispatchable Intermittent Resource
- HDD Heating Degree Days
- ELMP Extended Locational Marginal Price
- JCM Joint and Common Market Initiative
- JOA Joint Operating Agreement
- LAC Look-Ahead Commitment
- LSE Load-Serving Entities
- M2M Market-to-Market
- MSC MISO Market Subcommittee
- NCA Narrow Constrained Area
- ORDC Operating Reserve Demand Curve
- PITT Pseudo-Tie Issues Task Team
- PRA Planning Resource Auction
- PVMWP Price Volatility Make Whole Payment
- RAC Resource Adequacy Construct
- RDT Regional Directional Transfer
- RSG Revenue Sufficiency Guarantee
- RTORSGP Real-Time Offer Revenue Sufficiency Guarantee Payment
- STE Short-Term Emergency
- SMP System Marginal Price
- SOM State of the Market
- TLR Transmission Loading Relief
- TCDC Transmission Constraint Demand Curve
- VLR Voltage and Local Reliability
- WUMS Wisconsin Upper Michigan System